Chapter 4
Groundwater Quality

INTRODUCTION

California's groundwater is described by DWR as a "hidden resource." Management of groundwater resources is more complex than management of surface water because groundwater is not visible (DWR 2003). It is thought that California could not have achieved its agricultural economy, the fifth largest in the world, if it were not for the groundwater supply. Approximately 43 percent of the entire population of California obtains their drinking water from groundwater aquifers (DWR 2003). In some areas, the use of groundwater is threatened by the high rates of extraction and inadequate recharge or contamination of the aquifer from poor management practices.

This chapter provides a general description of groundwater quality and conditions in the three major hydrologic regions (HRs) in the Central Valley:

- Sacramento River
- San Joaquin River
- Tulare Lake

The Sacramento River Basin consists of 90 basins and subbasins. The San Joaquin Valley Groundwater Basin, which includes the San Joaquin River Hydrologic Region, the Tulare Lake Region, and several Small Groundwater Basins, consists of 28 basins and subbasins.

Importance of Groundwater

Groundwater is one of California's most important natural resources, and our reliance on it continues to grow. Statewide, groundwater supplies account for approximately 30 percent of the total urban and agricultural water supply in average years, approximately 40 percent of the total water supply in dry years, and as much as 60 percent or more in some regions in dry years. Groundwater provides from 30 to 41 percent of the total water supply for urban and agricultural uses in the Sacramento River, San Joaquin River, and Tulare Lake HRs (see Table 4-1). More than 70 percent of the groundwater used in California is supplied from the Sacramento River, San Joaquin River, and Tulare Lake HRs. (DWR 2003.) With such a large amount of water coming from these hydrologic regions, protection of their water resources is critical to ensure that future needs are met.

Table 4-1. Average Annual Groundwater Supply for the Sacramento River, San Joaquin River, and Tulare Lake Hydrologic Regions

Hydrologic Region	Total Demand Volume in TAF	Demand Met by Groundwater (TAF)	Demand Met by Groundwater (%)
Sacramento River	8,720	2,672	31
San Joaquin River	7,361	2,195	30
Tulare Lake	10,556	4,340	41

TAF = thousand acre feet.
Source: DWR 2003.

Interconnection of Groundwater and Surface Water

The connection between groundwater and surface water is important to address in the development of any program designed to protect water resources because the movement of water from one hydrologic system to another can move pollutants between the two systems. Groundwater is recharged by seepage of water moving downward from the ground surface. Groundwater can receive seepage from precipitation; from applied water to agricultural fields and landscaping; and from rivers, lakes, and water delivery systems. Patterns of recharge are dependent on land uses, the amount of groundwater pumped, and the amount of surface water available in any given year. Recharge from irrigation during summer is more significant than recharge from precipitation in winter in the larger groundwater basins in California's Central Valley(UC Regents 2003a). Groundwater may also be discharged to surface waters as baseflow to streams, river, or lakes; as runoff of groundwater applied to cropland, or as subsurface drainage discharges. (UC Regents 2003b.)

Generally, groundwater basins become more dewatered from north (Sacramento hydrologic region) to south (San Joaquin and Tulare Lake HRs). This pattern of dewatering is heavily influenced by the availability of surface water. In the early 1900s, the state and federal governments realized that the lack of surface water available to grow crops in the San Joaquin Valley was causing subsidence and other problems, as irrigated agriculture pumped ever-increasing amounts of groundwater to grow more crops. The CVP was built to deliver surface water to areas in the San Joaquin River and Tulare Lake HRs as a response to the reliance on groundwater and the need to curtail pumping from these aquifers.

Today, many cities in the San Joaquin Valley that depend on groundwater for drinking water rely on surface water delivery facilities for groundwater recharge. In wet years, many agricultural water users are encouraged to forego pumping groundwater in exchange for applying surface water, and many irrigation districts and municipal water agencies recharge groundwater through spreading basins designed to enhance recharge. This recharged water can then be used in drier years when surface water supplies are less available. This interconnectedness both supports better utilization of water resources and provides pathways for contamination to occur.

Reflecting the importance of groundwater as a source of supply in California, a number of federal, state, and local agencies have some responsibility to monitor and regulate groundwater. Each agency at the state and federal level has a different responsibility and approach to monitoring groundwater issues, based on their respective mandate. State agencies that implement groundwater monitoring and assessment programs are presented in Table 4-2. Federal agencies that implement groundwater-related monitoring and assessment programs in California include EPA, Reclamation, and USGS.

Table 4-2. Summary of Monitoring Programs by State Agency

Agency	Groundwater Program	Groundwater Monitoring/Assessment Objectives
Department of Public Health (CDPH)	California Drinking Water Source Assessment and Protection Program	Ascertain quality of all public water supply sources for compliance with maximum contaminant levels (MCLs). Complete source water assessments of all sources by May 2003. A source water assessment is required for all new sources before receiving a CDPH permit.
Department of Pesticide Regulation (DPR)	Ground Water Protection Program	Groundwater contaminant identification; Determine potential for movement of pesticide residues to groundwater based on their physical/chemical properties. Conduct well sampling to identify new pesticide active ingredients in groundwater. Provide monitoring data to determine trends in pesticide concentrations in contaminated basins. Vulnerable area identification; Determine the spatial extent of contamination for residues already detected in groundwater. Use soil type, depth to groundwater, climate, and other geographic or agronomic factors to identify areas vulnerable to pesticide contamination of groundwater. Mitigation measure development and implementation; Identify and test mitigation measures to prevent movement of residues to groundwater. Implement mitigation measures to prevent continued movement of pesticides to groundwater. Backflow and chemigation education and training; Prevent the backflow of residues into groundwater when they are applied through injection into irrigation water.
Department of Water Resources (DWR)	Bulletin 118	Update of groundwater basin boundaries and basin characteristics.
	Water quality and quantity monitoring	Long-term water quality and well level data.
	Local and regional studies	Miscellaneous groundwater studies addressing local groundwater issues.
	Groundwater quantity for updating the State Water Plan	State's water supply and demand budget.
	State Water Project Conjunctive Use Program	Basin monitoring associated with State Water Project conjunctive use projects.
	Integrated Storage Investigations, Conjunctive Use, and Grants and Loans Programs	Data collection, monitoring, and evaluation; feasibility studies for groundwater recharge and storage.
	Water data management systems	Water Data Library: on-line access to hydrologic data.
	Subsidence monitoring	Monitoring along California Aqueduct; special studies as needed.
State Water Resources Control Board (State Water Board)	Groundwater Ambient Monitoring and Assessment (GAMA) Program	Assess statewide groundwater quality and aquifer susceptibility.

Agency	Groundwater Program	Groundwater Monitoring/Assessment Objectives
State Water Board and Regional Water Quality Control Boards (Regional Water Boards)	Underground Storage Tank (UST) Program	Regulate USTs and provide cleanup oversight.
	Land Disposal Program	Impose statewide requirements for siting, operation, and closure of waste disposal sites through issuance of waste discharge requirements and compliance and enforcement efforts to ensure adequate protection of water quality.
	Site Cleanup	Oversee the investigation and remediation of sites associated with unauthorized releases that may impact water quality.
	Department of Defense (DOD) Program	Partner with DOD through the Defense and State Memorandum of Agreement (DSMOA) to oversee the investigation and remediation of water quality issues at over 200 military facilities.
Department of Toxic Substances Control (DTSC)	Hazardous Waste Management Program—Facility Permitting Division	Evaluate groundwater contamination at Resource Conservation and Recovery Act storage, treatment, and disposal facilities.
	Site Mitigation Program—Statewide Cleanup Operations Division	Evaluate groundwater contamination at Superfund, brownfield, and voluntary cleanup sites.
	Site Mitigation Program—Emergency Response and Statewide Operations Division	Evaluate groundwater contamination at Superfund, brownfield, and voluntary cleanup sites (technical support).
	Site Mitigation Program—Office of Military Facilities	Evaluate groundwater contamination at military sites.

Potential Agricultural Impacts to Groundwater Quality

Because irrigation is the primary source of recharge to the larger aquifers of the Central Valley, irrigation seepage can provide pathways for contamination in areas where groundwater aquifers underlie porous soils that receive heavy nutrient or chemical applications. While contamination of the aquifer can occur when water is applied to fields and landscaped areas, rainfall runoff also can carry agricultural pollutants that reach dry wells, ditches, sumps or ponds, and porous soils. Because many applications of pesticides to agricultural lands are from late fall to early spring, rainfall can transport pesticides to groundwater during this period (USGS 2004).

Figure 4-1 provides a conceptual model of the interconnection between groundwater and surface water, including possible sources of contaminants from irrigated agriculture. As shown in Figure 4-1, there are many potential pathways for irrigated agricultural pollutants to impact groundwater. Because of the many potential pathways and the existence of other pollutant sources (septic systems, dairies, etc.) it is difficult to determine where the pollutants originate from. Existing pollution could have been caused many years ago by practices no longer in use.

Numerous studies address the complex process of controlling the transport and fate of agricultural chemicals in surface water and groundwater. Not all of the applied agricultural chemicals remain in the soil or are taken up by the plant. A small percentage of the chemicals can move upward into the atmosphere, downward through the soil into shallow groundwater, or across the land into streams (USGS 2004). Chemicals that persist for long periods are more likely to be transported farther than short-lived compounds. According to DPR, pesticides that move to groundwater under certain soil conditions are most frequently found in groundwater when the depth to groundwater is shallower than 70 feet (DPR 2007a, 2007b).

Constituents of Concern in Groundwater Related to Agriculture

Table 4-3 presents the main constituents of concern for potential groundwater contamination from agricultural practices in the Sacramento River, San Joaquin River, and Tulare Lake HRs.

Table 4-3. Constituents of Concern related to Agricultural Practices in the Sacramento River, San Joaquin River, and Tulare Lake Hydrologic Regions

Constituent of Concern	Agricultural Source
Nutrients—primarily nitrate but may include nitrites, ammonia, and phosphorous	Organic and chemical fertilizers, animal wastes, and natural sources
Pesticides (insecticides and herbicides) and degradation products	Crop applications
Salt—primarily measured as electrical conductivity and total dissolved solids	Evaporation from shallow water table and evapotranspiration of soil water, fertilizers, irrigation water, natural soil salinity, and animal wastes
Trace elements (cadmium, copper, lead, nickel, zinc, selenium, arsenic, and boron)	Fertilizers, irrigation water, and natural sources
Organic carbon and disinfection byproduct precursors	Mobilization of soil organic matter and plant residues due to cultivation and irrigation
Microorganisms	Animal wastes

Nutrients

Essential plant nutrients occur naturally in soil. To increase crop yield, growers supplement soil nutrients by adding chemical fertilizers and organic fertilizers such as animal manures and crop residues. Because excess nutrients can move below the root zone, managing plant nutrients is an important part of protecting groundwater quality. The three major nutrients for plants are nitrogen, phosphorous, and potassium.

The primary nutrient of concern in the Central Valley is nitrogen. In soil, both organic and inorganic nitrogen are converted to highly leachable nitrate. The risk of nitrate leaching and contaminating groundwater is highest when; nitrogen applications exceed crop needs, timing of nitrogen application does not coincide with crop needs, soils are well drained, and excess rainfall or irrigation increases leaching. Nitrogen in drinking water is of concern because it can interfere with the ability of red blood cells to carry oxygen to the tissues of the body, producing a condition called methemoglobinemia. It is of greatest concern in infants, whose immature stomach environment enables conversion of nitrate to nitrite, which is then absorbed into the blood stream. Throughout this chapter are references to primary and secondary inorganic. A primary inorganic is defined as an inorganic mineral that has not been altered chemically since its deposition and crystallization from molten lava. A secondary inorganic is defined as an inorganic mineral resulting from the weathering of a primary mineral, either by an alteration in the structure or from reprecipitation of the products of weathering (dissolution) of a primary mineral.

Pesticides

Detection of pesticides in groundwater is related to physical and chemical properties of soils and the specific compounds, water management, and spatial and temporal variability of pesticide application and soil-water processes and properties. Factors that generally increase the degradation and soil adsorption of the pesticide reduce the probability of detection in groundwater. Throughout this chapter are references toverified and unverified pesticide detections. Verified pesticide detections are defined as those that are found at more than one sampling date resulting from legal or agricultural uses.

Water management practices also influence movement of pesticides in irrigated areas. Troiano et al. (1993) investigated different irrigation methods and found that “leaching of pesticides was less in sprinkler applications because water was applied more frequently in smaller applications than for the basin-flooding method.” For basin-flooding treatmentsa large amount of water application is required for each irrigation to provide application across the plot. Although irrigations are less frequent, the larger water volume may cause greater downward movement of water and associated pesticides.

Salinity

Irrigated agriculture can result in increasing groundwater salinity. Irrigation water containing varying levels of dissolved constituents or salts is partially evaporated as the result of crop transpiration and evaporation from the soil. These processes concentrate salts in the remaining water that percolates to groundwater. The extent of the effect on groundwater salinity depends on rainfall, volume of water applied, groundwater pumping and hydraulics, the salinity of the irrigation water, and chemical reactions in soils and aquifer materials.

Organic Carbon and Disinfection Byproducts

Disinfection byproducts form when disinfectants added to drinking water to kill germs react with naturally-occurring organic matter in surface water or groundwater. These disinfection byproducts have been a source of concern in recent years. While most groundwater does not contain elevated levels of organic material, increased scrutiny has been placed on monitoring for these precursors.

Microorganisms

All natural waters (rivers, lakes, wetlands) contain microorganisms. Groundwater usually has fewer microorganisms than surface water because of its long travel time in the subsurface environment. However, groundwater can become contaminated by domestic sewage, feedlots, and surface runoff, as well as other pollution sources. Where the subsurface geology permits rapid downward movement of water from the surface, or where the groundwater sources are tapped near the surface, aquifers may be vulnerable.

Groundwater Vulnerability to Pollution

Considerable effort has been expended in California to determine areas that are vulnerable to groundwater pollution from various sources. The California Drinking Water Source Assessment and Protection Program (DWSAP) prepared and administered by CDPH, and the Ground Water Protection Program developed and administered by DPR are two programs in California that were developed to determine areas where groundwater is vulnerable to pollution.

DPR's DWSAP Program was prepared in response to the 1996 reauthorization of the federal Safe Drinking Water Act (SDWA), which included an amendment requiring states to develop a program to assess sources of drinking water and encouraging states to establish protection programs. The drinking water source assessment is the first step in the development of a complete drinking water source protection program. The assessment includes a delineation of the area around a drinking water source through which contaminants might move and reach that drinking water supply. In addition, it includes an inventory of activities that might lead to the release of microbiological or chemical contaminants within the delineated area. This enables a determination to be made as to whether the drinking water source might be vulnerable to contamination. Finally, CDPH will work with the local drinking water providers to determine management practices in order to protect the drinking water from sources of contamination (CDPH 2000).

The Ground Water Protection Program determines where and how pesticides are contaminating groundwater, identifies areas sensitive to pesticide contamination, and develops mitigation measures to prevent further movement. DPR also adopts regulations and does outreach to carry out mitigation measures. The measures are designed to prevent continued movement to groundwater in contaminated areas and to prevent problems before they occur in other areas. DPR developed computer modeling that identified vulnerable areas of the state by using almost 20 years of well monitoring data compiled in DPR's well inventory database, as well as soil data from the NRCS and climate information. This model provides DPR with the tools to relate farming practices and soil conditions to the use of soil-applied herbicides that most often threaten groundwater. Vulnerable areas are classified as either "runoff" or "leaching." and management practices are written into regulation for each area type. Administration and enforcement of the program is carried out within the existing permit process and gives pesticide users flexibility to choose from a menu of regulatory options to apply the protection measure that best fits their situation. (DPR 2004a.)

Other programs also are actively working to identify vulnerable areas to various forms of pollution. Among them are the CDFA Fertilizer and Research Program (FREP) and the State Water Board and USGS Groundwater Ambient Monitoring Assessment (GAMA) Program. The FREP funds and coordinates research to advance the environmentally safe and agronomically sound use and handling of fertilizer materials. FREP serves growers, agricultural supply and service professionals, extension personnel, public agencies, consultants, and other interested parties. The GAMA Program has evaluated the susceptibility of groundwater to contamination in several areas of the state. The California Aquifer Susceptibility assessment (CAS) was performed from 2000 to 2003 in collaboration with USGS and Lawrence Livermore National Laboratory. CAS was a study of the water quality and relative susceptibility of groundwater that serves as a source for public drinking water. GAMA also prepared a map showing areas of California with the potential to be more susceptible to groundwater contamination based on chemical analysis (see <http://www.waterboards.ca.gov/water_issues/programs/gama/>). (Moran et al. 2004.)

Organization and Elements

This discussion of groundwater quality in the Sacramento River, San Joaquin River, and Tulare Lake HRs is organized by groundwater basin and subbasin. The introduction for each groundwater basin includes an overview of agricultural impacts on groundwater, groundwater movement and solute transport, general hydrogeology, and groundwater development. Individual subbasin sections include discussions of general basin parameters (acreage, physiography, major sources of recharge, land uses, coalitions, water districts, major urban areas, and pertinent ordinances or regulations) and water quality data.

Figure 4-2 displays the locations of groundwater subbasins within the Sacramento River hydrologic region, Figure 4-3 displays the locations of groundwater subbasins within the San Joaquin River, and Figure 4-4 displays the locations of groundwater subbasins in the Tulare Lake hydrologic region. The groundwater quality descriptions are organized in alphabetical order by large subbasins in the Sacramento River HR and San Joaquin River and Tulare Lake HRs, followed by descriptions of the smaller basins peripheral to them.

General Sources of Information

Sources of information for each subbasin include reports and data from DWR, DPR, and USGS. Specifically, land use data came from the DWR land use surveys conducted periodically throughout California. DWR Bulletin 118 (DWR 2003) was the primary source of information for subbasin hydrogeologic and physiographic descriptions for the Sacramento Valley, San Joaquin Valley and Tulare Lake Groundwater Basins.

Water quality data were obtained from DPR (Schuette et al. 2003), DWR Bulletin 118, and other published documents. Several USGS reports provided information about concentrations of constituents in the Sacramento Valley Groundwater Basin. The DPR data are county-specific, not specific to the individual subbasins. Regulatory and groundwater management information was obtained from various DWR publications as well as from various county websites. Population information was obtained from county and individual city websites. Information regarding groundwater ordinances and regulation was obtained from DWR Bulletin 118 (DWR 2003) and by contacting individual counties.

DPR’s Ground Water Protection Program provided information useful for determining where and how pesticides are contaminating groundwater, and identifying areas sensitive to pesticide contamination. Other literature was reviewed and cited that explains agriculture-related processes affecting groundwater quality in general and for specific subbasins. Included were peer-reviewed journal articles and preliminary data and reports from the GAMA Program funded by the State Water Board.

GROUNDWATER BASINS

The groundwater basins within the three major hydrologic regions of the Central Valley have been delineated using the boundaries in DWR Bulletin 118. Figures 4-2 through 4-4 show the boundaries of these basins.

Sacramento River Basin

- Sacramento Valley Basin
- Alturas Area Basin
- American Valley Basin
- Antelope Creek Basin
- Ash Valley Basin
- Bear Valley Basin
- Berryessa Valley Basin
- Big Valley Basin (No. 5-15)
- Big Valley Basin (No. 5-4)
- Blanchard Valley Basin
- Burney Creek Valley Basin
- Burns Valley Groundwater Basin
- Butte Creek Valley Basin
- Cayton Valley Basin
- Chrome Town Area Basin
- Clear Lake Cache Formation Basin
- Clover Valley Basin
- Collayomi Valley Groundwater Basin
- Coyote Valley Basin
- Dixie Valley Basin
- Dry Burney Creek Basin
- Egg Lake Valley Basin
- Elk Creek Area Basin
- Fairchild Swamp Area Basin
- Fall River Valley Basin
- Funks Creek Basin
- Goose Valley Basin
- Goose Lake Valley Basin
- Grays Valley Basin
- Grizzly Valley Basin
- High Valley Basin
- Hot Springs Valley Basin
- Humbug Valley Basin
- Indian Valley
- Jess Valley Basin
- Joseph Creek Basin
- Lake Almanor Valley Basin
- Lake Britton Area Basin
- Last Chance Creek Valley Basin
- Little Indian Valley Basin
- Long Valley Basin (No. 5-31)
- Long Valley Basin (No. 5-44)
- Lower Lake Basin
- McCloud Area Basin
- Meadow Valley Basin
- Middle Creek Basin
- Middle Fork Feather River Basin
- Mohawk Valley Basin
- Mountain Meadows Valley
- North Fork Battle Creek Basin
- North Fork Cache Creek Basin
- Pondosa Town Area Basin
- Pope Valley Basin
- Redding Area Basin
- Rock Prairie Valley Basin
- Round Valley Basin
- Scotts Valley Basin
- Sierra Valley Basin
- Squaw Flat Basin
- Stony Gorge Reservoir Basin
- Stonyford Town Area Basin
- Toad Well Basin
- Upper Lake Basin
- Yellow Creek Valley Basin

San Joaquin Valley Groundwater Basin

San Joaquin River Hydrologic Region

- Cosumnes Subbasin
- Eastern San Joaquin Subbasin
- Tracy Subbasin
- Modesto Subbasin
- Turlock Subbasin
- Merced Subbasin
- Delta-Mendota Subbasin
- Chowchilla Subbasin
- Madera Subbasin

Tulare Lake Hydrologic Region

- Westside Subbasin
- Kings Subbasin
- Tulare Lake Subbasin
- Kaweah Subbasin
- Tule Subbasin
- Pleasant Valley Subbasin
- Kern County Subbasin

Small Groundwater Basins

- Panoche Valley
- Kern River Valley
- Walker Basin Creek Valley
- Cummings Valley
- Tehachapi Valley West
- Castaic Lake Valley
- Vallecitos Creek Valley
- Brite Valley
- Cuddy Canyon Valley
- Cuddy Ranch Area
- Cuddy Valley
- Mil Portero Area

SACRAMENTO RIVER BASIN—INTRODUCTION

Overview of Agricultural Chemical Impacts to Groundwater

The information provided here focuses on the occurrence of groundwater contamination due to irrigated agriculture in the Sacramento River Basin. Table 4-4 summarizes the results of the review of the available information. Twenty-five percent of the basins or subbasins have insufficient data or available data indicate no groundwater quality problems. In a large number of the basins or subbasins (30%), irrigated agriculture occupies 5% or less of the area.

Table 4-4. Summary of Groundwater Quality Issues for the Sacramento River Hydrologic Region

Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-21	Sacramento Valley		
5-21.54	Antelope	Nitrate concentrations of 20–45 mg/L observed in the west-central part of the subbasin.	44
5-21.53	Bend	No apparent problems.	3
5-21.52	Colusa	Elevated groundwater salinity and concentrations of nutrients and rice pesticides.	66
5-21.51	Corning	Possibly salinity.	35
5-21.55	Dye Creek	Possibly salinity.	20
5-21.59	East Butte	Pesticides and nitrates are the primary constituents of concern. There are also localized areas of high salinity.	60
5-21.56	Los Molinos	Possibly salinity. Insufficient data to determine effects of irrigated agriculture.	18
5-21.64	North American	Nitrates, pesticides, dissolved solids, and VOCs are the result of agricultural and urban land uses.	38
5-21.60	North Yuba	Nutrients (nitrogen, phosphorus), salinity, pesticides, and trace elements are the primary constituents of concern. Trace elements are thought to be naturally occurring but some are elevated to levels above the national limits. There is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides from irrigated agriculture in the North Yuba Subbasin.	71
5-21.50	Red Bluff	Salinity.	10
5-21.66	Solano	High levels of pesticides, nitrates, and salinity are possibly related to irrigated agriculture.	65
5-21.65	South American	High levels of pesticides, nitrates, and salinity are possibly related partially to irrigated agriculture and partially to urban land uses.	25

Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-21.61	South Yuba	Pesticides and increasing salinity are the primary constituents of concern related to irrigated agricultural practices.	48
5-21.62	Sutter	Pesticides and increasing salinity are the primary constituents of concern related to irrigated agriculture. Localized high nitrogen concentrations may be caused by agricultural practices.	79
5-21.57	Vina	Groundwater quality problems include localized high calcium and high nitrate, TDS, and VOCs—primarily in the Chico area. It is uncertain whether these contaminants originate from agricultural practices. High nitrates are likely from septic systems. Dissolved solids may originate from irrigation practices, but it is uncertain.	36
5-21.58	West Butte	Dissolved solids are elevated in localized areas throughout the subbasin, and pesticides have been detected in groundwater beneath the rice growing areas. Trace elements are thought to be naturally occurring, as well as nitrates in some locations. However, there is evidence of elevated groundwater salinity and concentrations of nutrients and pesticides as the result of irrigated agriculture.	70
5-21.67	Yolo	High dissolved solids and nitrate are related to irrigated agriculture. Pesticides detected though insufficient dataare available to determine the effects of irrigated agriculture.	66
5-2	Alturas Area		
5-2.01	South Fork Pitt River	Salinity in localized areas	31
5-2.02	Warm Springs Valley	Salinity in localized areas	23
5-91	Antelope Creek	No groundwater quality data available.	5
5-54	Ash Valley	No water quality data available. All agricultural land is pasture.	37
5-64	Bear Valley	Insufficient water quality data.	5
5-20	Berryessa Valley	No irrigated agriculture in this basin.	0
5-15	Big Valley	Increasing levels of nitrate in individual wells may be the result of irrigated agriculture.TDS ranges from 270 to 790 mg/L, averaging 535 mg/L, which is above the EPA SMCL, may also be the result of irrigated agriculture. Elevated levels of iron and boron are caused by thermal waters.	37

Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-4	Big Valley	Localized high levels of nitrates, manganese, fluoride, iron, sulfate, conductivity, calcium, adjusted sodium absorption ratio, ammonia, phosphorus, and TDS. Pastureland comprises 28% of the basin and may be the cause for nitrates, phosphorus, ammonia, and dissolved solids.	37
5-92	Blanchard Valley	No groundwater quality data available.	10
5-48	Burney Creek Valley	Insufficient water quality data available to determine effects of irrigated agriculture. All agricultural land is pasture.	41
5-17	Burns Valley	No indication that groundwater quality problems are due to agricultural irrigation.	19
5-51	Butte Creek Valley	No irrigated agriculture in this basin.	0
5-21.68	Capay Valley	Dissolved solids from six wells range from 300 to 500 mg/L, the EPA MCL is 500 mg/L.. Insufficient dataare available to determine the effects of irrigated agriculture.	31
5-45	Cayton Valley	No groundwater quality data available. All agricultural land is pasture.	69
5-61	Chrome Town Area	No irrigated agriculture in this basin.	0
5-66	Clear Lake Cache Formation	Insufficient water quality data.	1
5-58	Clover Valley	No irrigated agriculture in this basin.	0
5-19	Collayomi Valley	No apparent agriculturally related groundwater quality problems.	10
5-18	Coyote Valley	No apparent agriculturally-related groundwater quality problems.	28
5-53	Dixie Valley	No groundwater quality data available. All agricultural land is pasture.	51
5-49	Dry Burney Creek Valley	No irrigated agriculture in this basin.	0
5-41	Egg Lake Valley	No irrigated agriculture in this basin.	0
5-62	Elk Creek Area	No groundwater quality data available	6
5-5	Fall River Valley	Localized high concentrations of nitrate, manganese, ammonia, and phosphorus. Pastureland comprises 31% of the land use.	43
5-90	Funks Creek	Insufficient groundwater quality data.	17
5-47	Goose Valley	No groundwater quality data available.	92
5-1	Goose Lake Valley	Insufficient data.	
5-1.02	Fandango Valley	Insufficient data.	25
5-1.01	Lower Goose Lake Valley	Insufficient data.	26
5-52	Grays Valley	No irrigated agriculture in this basin.	0
5-59	Grizzly Valley	No irrigated agriculture in this basin.	0
5-16	High Valley	TDS ranges from 480 to 745 mg/L, averaging 598 mg/L, which is above the EPA SMCL. Locally high ammonia, boron, phosphorus, chloride, iron, and manganese.	8

Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-40	Hot Springs Valley	No groundwater quality data available. All agricultural land is pasture.	10
5-60	Humbug Valley	Insufficient groundwater quality data.	4
5-3	Jess Valley	Insufficient data.	53
5-86	Joseph Creek	No groundwater quality data available.	20
5-46	Lake Britton Area	No irrigated agriculture in this basin.	0
5-57	Last Chance Creek Valley	No irrigated agriculture in this basin.	0
5-65	Little Indian Valley	Insufficient data.	24
5-31	Long Valley	Insufficient data	24
5-44	Long Valley	No irrigated agriculture in this basin.	0
5-30	Lower Lake Valley	High boron. Localized high iron, manganese, calcium, sodium, sulfate, and TDS. Insufficient data to determine effect of irrigated agriculture.	6
5-35	McCloud Area	No irrigated agriculture.	0
5-95	Meadow Valley	Insufficient groundwater quality data.	5
5-94	Middle Creek	No groundwater quality data available.	5
5-87	Middle Fork Feather River	Insufficient groundwater quality data.	4
5-50	North Fork Battle Creek	No groundwater quality data available.	6
5-93	North Fork Cache Creek	No irrigated agriculture.	0
5-38	Pondosa Town Area	No information available about the basin.	–
5-68	Pope Valley	No groundwater quality data available. Almost all agricultural land is vineyards.	28
5-6	Redding Area		
5-10	American Valley	Insufficient groundwater quality data.	42
5-6.03	Anderson	Localized high nitrate may be due to irrigated agriculture.	13
5-6.01	Bowman	No known groundwater quality problems due to agricultural land use.	3
5-6.04	Enterprise	. No known groundwater quality problems due to agricultural land use.	9
5-9	Indian Valley	Insufficient groundwater quality data.	39
5-7	Lake Almanor Valley	No apparent groundwater quality problems due to irrigated agriculture.	19
5-6.05	Millville	No known groundwater quality problems due to agricultural land use.	4
5-11	Mohawk Valley	No known groundwater quality problems due to agricultural land use..	7
5-8	Mountain Meadows Valley	Insufficient groundwater quality data.	46
5-6.02	Rosewood	No known groundwater quality problems.	4
5-6.06	South Battle Creek	No known groundwater quality problems.	6
5-43	Rock Prairie Valley	No irrigated agriculture.	0

Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-36	Round Valley	TDS ranges from 141 to 633 mg/L, averaging 260 mg/L. Most agricultural land is pastureland. Insufficient information to determine effects of irrigated agriculture.	34
5-14	Scotts Valley	Nitrate, iron, manganese, and boron concentrations exceed EPA maximum acceptable concentrations for agricultural irrigation for selected wells. Insufficient information to determine effects of irrigated agriculture.	22
5-12	Sierra Valley	Insufficient data.	
5-12.02	Chilcoot	Localized high dissolved solids.	25
5-12.01	Sierra Valley	Localized high dissolved solids, boron, fluoride, iron, sodium, arsenic, manganese. Thermal groundwater intrusion is the most likely source for these constituents.	31
5-89	Squaw Flat	No irrigated agriculture in this basin.	0
5-88	Stony Gorge Reservoir	No groundwater quality data available.	4
5-63	Stonyford Town Area	Insufficient groundwater quality data.	12
5-37	Toad Well Area	No irrigated agriculture in this basin.	0
5-13	Upper Lake Valley	Localized high salinity likely due to irrigated agriculture.	42
5-56	Yellow Creek Valley	No water quality data available. All agricultural land is pasture.	61

Notes:
EPA = U.S. Environmental Protection Agency.
MCL = Maximum Contaminant Level (EPA 2005).
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Limit (EPA 2005).
TDS = total dissolved solids.
VOCs = volatile organic compounds.
* Basin/Subbasin Number from California Department of Water Resources Bulletin 118.

Results from monitoring that was performed as part of the DPR Ground Water Protection Program are summarized in Table 4-5.

Table 4-5. Pesticide Detections in Groundwater Wells for Counties in the Sacramento River Basin (1985–2003)

County	ACET	Atrazine	Bentazon	Bromocitl	DACT	DEA	Diuron	Norflurazon	Promoton	Simizine
Butte		6	8	1		1	1	2	1	1
Colusa	2		7			1			1	4
Glenn		23	21			4	2		5	11
Placer			1	1						
Sacramento		1	1							
Shasta	1				1					
Solano	6	13			3	9	4	1	1	1
Sutter			5							2
Tehama	1	3				2	1			2
Yolo		5	3							3
Yuba			8							
Total	**10**	**51**	**54**	**2**	**4**	**17**	**8**	**3**	**8**	**24**

Notes:
ACET = 2-amino-4-chloro-6-ethylamino-s-triazine.
DACT = 2,4-diamino-6-chloro-s-triazine.
DEA = deethyl-atrazine.
Source: DPR Ground Water Protection Program. 2003 Well Inventory Database, Cumulative Report 1986-2003

SACRAMENTO RIVER BASIN—SUBBASINS

Antelope Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Antelope subbasin is bounded on the west by the Sacramento River, on the north by the Red Bluff Arch, on the northeast by the Cascade Range, and the southeast by Antelope Creek. The Antelope subbasin is contiguous with the Dye Creek Subbasin to the south. The subbasin is 18,710 acres (29 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Antelope subbasin is taken from DWR Bulletin 118 (DWR 2004). The aquifer system in this subbasin is comprised of continental deposits of Tertiary to late Quaternary age. The Quaternary deposits include Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include the Pliocene Tehama Formation and the Tuscan Formation. The Tuscan Formation is the primary water-producing zone in the basin.

The Pleistocene Modesto Formation consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tehama, Tuscan, and Riverbank Formations. Well logs for wells drilled on the floodplain east of Red Bluff indicate that coarse-grained clean sand and gravel extend to a depth of approximately 50 feet below the surface. Below this depth, cemented gravel, sandstone, and hard clay of the Tehama and Tuscan Formations are encountered. The Modesto Formation yields limited groundwater due to its limited thickness.

The Pleistocene Riverbank Formation is observed in the far northern extents of the subbasin. The Riverbank Formation yields limited groundwater due to its limited thickness and areal extents.

The Pliocene Tuscan Formation is composed of volcanic breccia, tuff, tuff breccia, volcanic sandstone and conglomerate, basalt flows, and tuffaceous silt and clay. The formation is mostly consolidated tuff in the area of exposure east of the valley in the Cascade Range foothills. From there tuff breccias grade westerly into volcanic sands, gravels, and clay (DWR 1978). The Tuscan Formation is the major water-bearing aquifer in the northeastern portion of the Sacramento Valley. Thickness of the formation within the subbasin is approximately 1,500 feet.

The Pliocene Tehama Formation interfingers with the Tuscan Formation along the Sacramento River and is exposed in Westside Sacramento River banks. The formation consists of fluvial deposits of predominantly silt and clay with gravel and sand interbeds. The formation is identified within the subbasin at depths ranging from 100 to 150 feet.

Long-term groundwater levels indicate a decline of 5–10 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Generally, groundwater level data show a seasonal fluctuation of approximately 2–15 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in groundwater levels.

Groundwater storage capacity was estimated to be 269,200 acre-feet. This estimate was based on an average specific yield of 7.2% and an assumed thickness of 200 feet.

Estimate of groundwater extraction for agricultural use is estimated to be 17,000 acre-feet. The Antelope aquifer system appears to be leaky, allowing water from shallow aquifers to percolate into deeper water (DWR 1987).

Major Sources of Recharge

Recharge to the subbasin is from precipitation (23–27 inches/year), irrigation infiltration, stream infiltration, and infiltration from on-site domestic waste disposal systems.

Stream infiltration comes from the Sacramento River, Salt Creek, and Antelope Creek. In an investigation conducted by Reclamation, the upper and intermediate aquifer zones (located between the local groundwater elevation and 150 feet in depth) were found to intercept the Sacramento River. Diurnal fluctuations in river stage produce diurnal water level fluctuations in the deeper aquifer zone.

A 1987 study of the Antelope Groundwater Subbasin by DWR stated that seepage from Lake Red Bluff raised groundwater levels 5–10 feet in the southern part of the subbasin since 1966, when then diversion dam gates were first closed.

Municipal and industrial use is approximately 2,100 acre-feet. Deep percolation of applied water is estimated to be 3,800 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 49% of the subbasin, urban land use accounts for about 10% of the subbasin, and native land accounts for about 41% of the subbasin. The primary crop types in the region are orchards and pasture. Table 4-6 provides details of the land uses within the subbasin.

Table 4-6. Land Use in the Antelope Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	20	0.10
Deciduous Fruits and Nuts	5,730	30.60
Field Crops	180	1.00
Grain and Hay	490	2.60
Pasture	1,730	9.30
Truck, Nursery, and Berry Crops	20	0.10
Idle	880	4.70
Semiagricultural and Incidental	150	0.80
Subtotal	9,200	49.20
Urban		
Urban—unclassified	100	0.50

Land Use	Acreage of Land Use	Percent of Land Use
Urban Landscape	60	0.30
Urban Residential	1,190	6.40
Commercial	190	1.00
Industrial	80	0.40
Vacant	300	1.60
Subtotal	1,920	10.30
Native		
Native Vegetation	6,000	32.10
Barren and Wasteland	120	0.60
Riparian	990	5.30
Water	470	2.50
Subtotal	7,580	40.50
Total	**18,700**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Antelope groundwater subbasin is within the Shasta-Tehama Watershed. The public agencies within the Antelope subbasin are the Tehama County Flood Control and Conservation District and the City of Red Bluff. Tehama County adopted a groundwater ordinance in 1994 and a countywide Assembly Bill 3030 (AB 3030) groundwater management plan in 1996. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use, and influence of well pumping restrictions. The city of Red Bluff is located partly within the subbasin. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater in the subbasin is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. TDS ranges from 119 to 558 mg/L, averaging 280 mg/L. High concentrations of boron, chloride, and TDS are found in groundwater in the vicinity of Salt Creek and Little Salt Creek. Nitrate concentrations of 20–45 mg/L have been observed within the west-central portion of the basin (DWR 2004).

A 1987 study by DWR stated that the quality of the groundwater in the subbasin is generally good. At that time it had a median concentration of dissolved solids of 296 mg/L. The current (2005) national secondary drinking water standard for dissolved solids is 500 mg/L. The median alkalinity, or hardness[1], of the water was 134 mg/L as $CaCO_3$.

[1] Water hardness is primarily the amount of calcium and magnesium in the water. Water hardness is measured by adding up the concentrations of calcium, magnesium and converting this value to an equivalent concentration of calcium carbonate ($CaCO_3$).

According to Tehama County (2003), a recent groundwater quality issue is related to increased levels of fecal coliform and nitrates in the Antelope area, which is just east of the city of Red Bluff. Fifty-two percent of the wells tested for nitrates in 2002 showed concentrations greater than 22.5 mg/L, including 20% that had concentrations greater than 45 mg/L. Forty-eight percent of the wells tested for coliform in 2002 showed a presence of the organism. Because the majority of wells with detections of nitrates and coliform were located in a developed area (previously agricultural land) with septic systems, DWR concluded that the most likely sources are the individual septic systems.

Dissolved Solids

The 1987 study by DWR found the concentration of dissolved solids in 75 groundwater wells to range from 140 to 558 mg/L with a median concentration of 296 mg/L. Electrical conductivity[2] from 72 wells ranged from 205 to 980 µohms/cm at 25 degrees C, with a median of 450 µohms/cm. These median values are within the acceptable range for domestic and irrigation use.

Nitrate

High nitrate concentrations (20–45 mg/L) were found throughout the west-central (north and west of State Highway 36 between Kaer and Trinity Avenues) portion of the subbasin. Concentrations above 3 mg/L are indicative of human induced contamination. The most probable sources of nitrogen in the subbasin are domestic wastes from septic systems and fertilizers. Another factor that may contribute to the movement of nitrate downward into the aquifer is the poor quality surface seals on some wells in the area (DWR 1987).

Boron

High boron concentrations were found in groundwater underlying Salt Creek and Little Salt Creek. This groundwater also contained high chloride and dissolved solids and a high adjusted sodium adsorption ratio (ASAR)[3], which indicates salt build-up in the sediments. Water is this area may harm sensitive crops. The boron in the groundwater in naturally occurring and is derived from marine rocks like those in the recharge areas for Salt Creek and Little Salt Creek (DWR 1987).

Pesticides

Antelope Valley subbasin contains 49% agricultural land uses. The DPR tests groundwater wells for pesticides on a regular basis. In Tehama County, in which Antelope Valley subbasin is located, DPR verified the detection of 5 different pesticides in the groundwater: ACET, bentazon, DEA, diuron, and simizine. These pesticides were detected 1, 7, 2, 1, and 3 times respectively.

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[2] Electrical conductivity (EC) is a measure of how well the water accommodates the transport of electric charge. EC estimates the amount of total dissolved salts, or the total amount of dissolved ions in the water.
[3] Adjusted sodium adsorption ratio (ASAR) is calculated from the ratio of soluble sodium to calcium and magnesium, adjusted for the precipitation or dissolution of Ca^{2+} in waters containing significant amounts of bicarbonate.

Bend Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Sacramento River serves as the subbasin boundary to the west and the Cascade Range to the east. The subbasin is bounded on the north by the hydrologic divide between the Redding and Sacramento groundwater basins along the north side of Paynes Creek. The anticlinal structure above the projected trace of the Red Bluff fault serves as the subbasin boundary to the south. The subbasin is about 21,760 acres (34 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Bend subbasin is taken from DWR Bulletin 118 (DWR 2004).

The Bend subbasin aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include stream channel deposits, Holocene alluvium, and Pleistocene deposits of Modesto and Riverbank Formations. The Tertiary deposits include the Tuscan Formation.

Holocene Alluvial deposits in the subbasin consist of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank Formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene. They are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. The thickness ranges up to 50 feet. The deposits are highly permeable and yield limited domestic water supplies.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers and is the principal water-bearing formation in the subbasin. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates in the eastern and northern parts of mapped unit. The formation is approximately 430 feet thick.

Unit C is the primary surficial deposit and consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. The thickness of Unit C exposed in the vicinity of Tuscan Springs and Tuscan Buttes ranges from 165 to 265 feet. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The deposit varies in thickness from 30 to 160 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (23–31 inches/year), infiltration of applied water, and stream infiltration.

Estimate of groundwater extraction for agricultural use is estimated to be 220 acre-feet. Municipal and industrial use is approximately 120 acre-feet. Deep percolation of applied water is estimated to be 340 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 3% of the subbasin, urban land use accounts for about 2% of the subbasin, and native land accounts for about 95% of the subbasin. The primary crop types in the region are pasture, orchards, and grains. Table 4-7 provides details of the land uses within the subbasin.

Table 4-7. Land Use in the Bend Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	50	0.20
Field Crops	20	0.10
Grain and Hay	150	0.70
Pasture	360	1.70
Truck, Nursery, and Berry Crops	20	0.10
Idle	40	0.20
Semiagricultural and Incidental	10	0.05
Subtotal	650	3.00
Urban		
Urban Landscape	10	0.05
Urban Residential	220	1.00
Commercial	10	0.05
Industrial	10	0.05
Vacant	80	0.40
Subtotal	330	1.50
Native		
Native Vegetation	20,200	93.00
Barren and Wasteland	50	0.20
Riparian	150	0.70
Water	340	1.60
Subtotal	20,740	95.50
Total	**21,720**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Bend groundwater subbasin is within the Shasta-Tehama Watershed. The public agency operating within the subbasin is the Tehama County Flood Control and Water Conservation District. Tehama County adopted a groundwater ordinance in 1994 and a countywide AB 3030 groundwater management plan in 1996. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use, and influence of well pumping restrictions. No urban areas are located within the sub-area. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater in the subbasin is characterized as magnesium-calcium bicarbonate. TDS ranges from 334 to 360 mg/L. Localized high calcium concentrations occur in the basin.

Discharge Pathways and Sources of Contaminants

Specific discharge pathways or sources of contaminants could not be identified.

Capay Valley Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Capay Valley subbasin is 25,000 acres (39 square miles) in size and located within the Coast Ranges in the western portion of Yolo County. It is defined by depositional sediments within the northwest-southeast trending Capay Valley. The subbasin extends from the Yolo County boundary on the north end to the confluence of Salt Creek and Cache Creek on the south end. Structurally, the Capay Valley is a broad, elongated synclinal depression between the Blue Hills of the Vaca Mountains and the Rumsey Hills in the Coast Range Geomorphic Province (DWR 1961).

The following description of the hydrogeology in the Antelope subbasin is taken from DWR Bulletin 118 (DWR 2004).

Primary water bearing deposits within the Capay Valley subbasin include recent stream channel deposits and the Tehama Formation, which is underlain by older non-freshwater bearing Cretaceous Marine Rocks (DWR 1978; Wagner and Bortugno 1982).

Recent stream channel deposits consist of unconsolidated silt, fine- to medium-grained sand, gravel and occasionally cobbles deposited in and adjacent to Cache Creek and its tributaries. These deposits are moderately to highly permeable and range in thickness from approximately 0 to 150 feet (DWR 1978).

The Tehama Formation consists of moderately compacted silt, clay, and silty fine sand enclosing lenses of sand and gravel, silt and gravel, and cemented conglomerate. This formation can be seen outcropping along the edges of the Capay Valley, and in other places within the western Yolo, Colusa, and Solano Counties. The Tehama Formation within the Capay Valley is generally less than a few hundred feet thick, however is found in much greater thickness to the east in the Sacramento Valley. The permeability of the Tehama Formation is variable, but generally less than the overlying recent stream channel deposits units.

Cretaceous Marine Rocks make up the basement rock beneath the fresh water bearing deposits of the Capay Valley Subbasin. Consisting of consolidated sandstone and shale of marine origin, these basement rocks generally contain saline connate water and are not considered useable water bearing formations.

Recharge for the Capay Valley Subbasin comes primarily from Cache Creek. Additional recharge comes from surrounding minor tributaries, including Bear Creek. Bear Creek is the source of waters high in boron, and has an influence on water quality within Cache Creek and on groundwater extracted from Cache Creek deposits within the Capay and Sacramento Valleys (DWR 1961).

Groundwater levels within most of the Capay Valley Subbasin vary from approximately 10 to 40 feet below ground surface and remain relatively stable, even through dry years. Wells located in the higher elevations along the edge of the valley show a greater variability, and appear to be more impacted by dry years.

Groundwater storage for the Capay Valley region was calculated in DWR Bulletin 90 (1961) based on estimated specific yield values for three discrete intervals between the depths of 20 and 200 feet. It was estimated that the groundwater storage capacity of the Capay Valley is approximately 99,800 acre-feet. It can be assumed that the groundwater in storage for the Capay Valley is roughly equal to the groundwater storage capacity, since water levels tend to remain at relatively shallow depths.

Groundwater is pumped from the Capay Valley subbasin for domestic, municipal and irrigation purposes and discharges to Cache Creek in lower reaches of the Valley. Specific agricultural sources of groundwater contamination could not be identified.

Major Sources of Recharge

Recharge to the subbasin is from precipitation, irrigation infiltration, and stream infiltration. Stream infiltration comes from the Cache Creek and its tributaries. Bear Creek is a tributary that is high in boron that influences the water quality in the Capay Valley groundwater subbasin. Annual precipitation is about 25 inches at ridge tops.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land use accounts for about 38% of the subbasin, urban land use accounts for about 1% of the subbasin, and native land accounts for about 61% of the subbasin. Table 4-8 provides details of the land uses within the subbasin.

Table 4-8. Land Use in the Capay Valley Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	10	0.04

Land Use	Acreage of Land Use	Percent of Land Use
Deciduous Fruits and Nuts	3,920	15.66
Field Crops	220	0.88
Grain and Hay	2,550	10.19
Idle	1,670	6.67
Pasture	570	2.28
Semiagricultural and Incidental	130	0.52
Truck, Nursery, and Berry Crops	480	1.92
Vineyards	0	0.00
Subtotal	9,550	38.00
Urban		
Urban—unclassified	20	0.08
Commercial	0	0.00
Industrial	10	0.04
Urban Landscape	0	0.00
Urban Residential	120	0.48
Vacant	10	0.04
Subtotal	160	1.00
Native		
Native Vegetation	15,000	59.93
Water	320	1.28
Subtotal	15,320	61.00
Total	25,030	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Yolo County Flood Control and Water Conservation District is the only water agency in the basin. The towns of Rumsey, Guinea and Brooks are located within the subbasin. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater quality within the Capay Valley Subbasin is primarily the result of infiltration of Cache Creek and its tributaries and is generally of good quality. It is a calcium-sodium-bicarbonate type with moderate to very high hardness. Highly mineralized water from Bear Creek and North Fork Cache Creek is a primary source of mineral constituents, especially boron, in groundwater in the Capay Valley Subbasin (DWR 1961). TDS measured in water taken from 6 wells in the Capay Valley ranged from approximately 300 to 500 mg/L, and was comparable to that found in water samples taken from Cache Creek (EPA 2001; DWR 1961).

Colusa Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Colusa subbasin aquifer is bound by Stony Creek in the north, Cache Creek in the south, the Coast Ranges on the west, and the Sacramento River on the east. The aquifer system is 1,434 square miles in size and is located in parts of Colusa, Glenn, Yolo, and Tehama Counties.

The following description of the hydrogeology in the Colusa subbasin is taken from DWR Bulletin 118 (2004). The Colusa Subbasin aquifer system is composed of continental deposits of late Tertiary to Quaternary age. Quaternary deposits include Holocene stream channel and basin deposits and Pleistocene Modesto and Riverbank formations. The Tertiary deposits consist of the Pliocene Tehama Formation and the Tuscan Formation. All Formations consist of varying amounts of gravel, sand, silt, and clay. The Holocene Stream Channel deposits are the upper part of the unconfined zone and are moderately-to-highly permeable. The Holocene basin deposits are interbedded with the Stream Channel deposits, have low permeability, and yield low quality and quantity of water.

The Modesto deposits consist of moderately to highly permeable gravels, sands, and silts. Thickness of the formation ranges from less than 10 feet to nearly 200 feet across the valley floor. The Riverbank deposits are the older terrace deposits that consist of poorly to highly pervious pebble and small cobble gravels interlensed with reddish clay, sand, and silt. Thickness of the formation ranges from less than 1 foot to over 200 feet depending on location. The formation yields moderate quantities of water to domestic and shallow irrigation wells and provides water to deeper irrigation wells that have multiple zones of perforation. Generally, the thickness of the formation limits the water-bearing capabilities.

The Tehama Formation is the predominant water-bearing unit within the Colusa Subbasin and reaches a thickness of 2,000 feet. The formation occurs at depths ranging from a few feet to several hundred feet from the surface. The formation consists of moderately compacted silt, clay, and fine silty sand enclosing lenses of sand and gravel; silt and gravel; and cemented conglomerate. Occasional deep sands and thin gravels constitute a poorly to moderately productive, deep, water-bearing zone.

The Tuscan Formation occurs in the northern portion of the subbasin at an approximate depth of 400 feet from the surface and may extend to the west to the Greenwood Anticline east of Interstate Highway 5. The formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subbasin. Unit A is the oldest water-bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B.

Groundwater levels in the Colusa subbasin tend to fluctuate by 5 feet in normal and dry years. There is no consistent decreasing trend in the aquifer levels. DWR (2004) estimated the specific yield to be 7.1% and the storage capacity (to a depth of 200 feet) to be 13 million acre-feet (maf).

Major Sources of Recharge

Irrigation is the primary source of groundwater recharge to the subbasin. Regionally, stream infiltration and to a lesser extent precipitation are also sources of recharge. The Sacramento River, Stony Creek, Cache Creek, and the Glenn-Colusa Canal recharge the aquifer. Annual precipitation ranges from 17 to 27 inches with higher precipitation occurring to the west (DWR 2004). Twenty-four percent of the Colusa subbasin is used for rice cultivation where the fields are typically flooded for six months each year. Groundwater discharge occurs as evapotranspiration, loss to streams, and pumpage.

Land Uses

The Colusa subbasin is primarily utilized for irrigated farming, rice farming being the most prevalent. The second most prevalent land use in the subbasin is native vegetation. Both Glenn and Colusa Counties contain a wildlife refuge. Land use surveys were conducted within the basin by DWR from 1997 to 1999. Agricultural land use accounts for about 69% of the basin, urban land use accounts for less than 3% of the basin, and native land accounts for about 29% of the basin. Table 4-9 provides details on the distribution of land use throughout the Colusa subbasin.

Table 4-9. Land Use in the Colusa Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	5,057	0.55
Deciduous Fruits and Nuts	79,827	8.69
Field Crops	90,527	9.86
Grain and Hay	82,831	9.02
Vineyards	6,936	0.76
Pasture	47,494	5.17
Rice	217,573	23.69
Semiagricultural and Incidental	6,432	0.70
Truck, Nursery, and Berry Crops	76,603	8.34
Idle	17,863	1.94
Subtotal	631,143	68.72
Urban		
Urban—unclassified	2,699	0.29
Commercial	822	0.09
Industrial	4,135	0.45
Urban Landscape	528	0.06
Urban Residential	4,437	0.48
Vacant	12,036	1.31
Subtotal	24,657	2.68
Native		
Riparian	37,096	4.04
Native Vegetation	206,826	22.52
Water	15,755	1.72

Land Use	Acreage of Land Use	Percent of Land Use
Barren and Wasteland	2,950	0.32
Subtotal	262,627	28.60
Total	**918,427**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The public entities within the Colusa subbasin aquifer system are: Knights Landing WUA, Orland Unit WUA. Cortina Creek FC&WCD, Colusa County FC&WCD, and Yolo County FC&WCD Artois CSD, Butte City CSD, Hamilton City CSD, NE Willows CSD, Ord CSD, City of Colusa, City of Orland, City of Williams, 4-M WD, Chrome WD, Colusa County WD, Cortina WD, Davis WD, Dunnigan WD, Glenn Valley WD, Glide WD, Holthouse WD, Kanawha WD, La Grande WD, Orland-Artois WD, Princeton WD, Westside WD, and Yolo-Zamora WD, Glenn-Colusa ID, Maxwell ID, Princeton-Cordora-Glenn ID, Provident ID, Maxwell ID, Reclamation Districts (RDs) 108, 478, 730, 787, 1004, 2047, Arbuckle PUD, Maxwell PUD (DWR 2004).

The private entities within the Colusa subbasin aquifer system are: California Water Service Co., Colusa Drain Mutual Water Co., California Water Service Co., Roberts Ditch & Irrigation Co. Inc, Willow Creek Mutual Water Co. (DWR 2004).

Tehama County adopted a groundwater management ordinance in 1994. Glenn County adopted a groundwater management ordinance in 2000. Colusa County adopted a groundwater management ordinance in 1998. Yolo County adopted a groundwater management ordinance in 1996 (DWR 2004). These ordinances affect primarily the volume of groundwater that can be pumped and/or exported from the subbasin. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county.

This subbasin falls within the area included in the Sacramento Valley and Rice Coalition.

Water Quality

Groundwater quality issues in the Colusa subbasin include excess nutrients, dissolved solids, trace elements, and pesticides. Dissolved solids are elevated in localized areas throughout the subbasin and pesticides are persistent in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring, as well as nitrates in some locations. However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the Colusa subbasin. Tables 4-10 and 4-11 summarize the available data.

Table 4-10. Water Quality in the Colusa Subbasin

Constituent of Concern	Available Information about Groundwater Concentrations for Colusa Subbasin
Nutrients	Median NO_3 concentration under rice fields was 2mg/L (Domagalski et al. 2000). High concentrations of nitrates found in groundwater near the Colusa, Arbuckle, Knights Landing, and Willows. Localized areas throughout the subbasin have high ammonia, and phosphorus concentrations (DWR 2004). Nitrate, ammonia, phosphorus measured in shallow groundwater in rice growing areas (Dawson 2001a).
Pesticides (insecticides and herbicides) and degradation products	Dawson (2001a) reported pesticides detections in 89% of the 28 wells sampled, 82% of which were pesticides used on rice fields: bentazon, carbofuran, molinate, and thiobencarb. Bentazon was found in 71% of the wells.
Salt—primarily as electrical conductivity and total dissolved solids.	High EC, TDS, adjusted sodium absorption ratio (ASAR) in groundwater near the City of Colusa and Knight's Landing. Localized areas throughout the subbasin have high TDS. High TDS concentrations measured in shallow groundwater in rice growing areas (Dawson 2001a). In the western half of the Sacramento Valley south of Willows, groundwater contains TDS frequently in excess of 500 mg/L (DWR 1978).
Trace elements	High boron concentrations found near Knights Landing. Localized areas throughout the subbasin have high manganese, fluoride, and iron. Dawson (2001a) found concentrations of inorganic constituents that exceeded primary state and federal drinking water standards at least once in 25% of the wells. The inorganic constituents detected above the primary limits were boron, barium, cadmium, molybdenum, or sulfate. Secondary drinking water standards were exceeded at least once in 79% of the wells. The constituents detected above secondary limits were chloride, iron, manganese, specific conductance (EC), or dissolved solids. Mercury from mining—Cache Creek/Putah Creek
Organic carbon and disinfection byproduct precursors	Dissolved organic carbon elevated relative to expected background in some areas (Dawson 2001a).
Microorganisms	No available data

Notes:
EC = electrical conductivity.
mg/L = milligrams per liter
TDS = total dissolved solids.

Table 4-11. Concentrations of Constituents of Concern Detected in the Colusa Subbasin

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standard
Nutrients	Nitrate	Median 2mg/L (Domagalski et al. 2000)	Nitrate was reported to exceed the MCL in two public supply wells in the Colusa subbasin (Moran et al. 2004).
	Ammonia as N	0.02–0.46 mg/L	30 (HAL)
	Ammonia + organic N as N	0.3–0.7 mg/L	30 (HAL)
	Nitrate+Nitrite, as N	0.08–6.2 mg/L	10 (MCL)
	Nitrate as N	0.08–6.2 mg/L	10 (MCL)
	Nitrite as N	0.01–0.01 mg/L	1 (MCL)
	Orthophosphate, as P	0.01–0.36 mg/L	

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standard
	Phosphorus, as P	0.03–0.362 mg/L	
	Dissolved organic carbon, as C	0.3–6.8 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	*0.002*–0.026 µg/L	3 (MCL)
	Bentazon	0.06–*7.8* µg/L	18 (MCL)
	Bromacil	0.19 µg/L (one detection)	90 (HAL)
	Carbofuran	0.016–0.8 µg/L	18 (MCL)
	Desethyl atrazine	0.001–0.005 µg/L	
	Dichlorprop	*0.1* µg/L (one detection)	
	Diuron	0.04–0.09 µg/L	10 (HAL)
	Azinphos-methyl	*0.014* µg/L (one detection)	
	Molinate	*0.002*–0.056 µg/L	20 (MCL)
	Simazine	*0.002*–0.027 µg/L	4 (MCL)
	Tebuthiuron	*0.006* µg/L (one detection)	500 (HAL)
	Thiobencarb	0.006–0.025 µg/L	70 (MCL)
Salt—primarily as electrical conductivity and total dissolved solids.		120–1,220 mg/L, mean 391 mg/L (DWR 2004) 168–8,730 mg/L, median 532 (Dawson 2001a)	
Trace elements	Aluminum	0.002–0.010 mg/L	1 (MCL)
	Arsenic	0.001–0.015 mg/L	
	Barium	0.01–5.05 mg/L	1(MCL)
	Boron	0.02–1.8 mg/L	0.6 (HAL)
	Bromide	0.03–12 mg/L	
	Cadmium	0.006–0.007 mg/L	0.005 (MCL)
	Chromium	0.002–0.016 mg/L	0.05 (MCL)
	Cobalt	0.001–0.004 mg/L	
	Copper	0.001–0.003 mg/L	1.3 (MCL)
	Ferrous Iron Fe2+	Detected in 19/28 wells	
	Fluoride	0.1–1.8 mg/L	4 (MCL)
	Iron Fe	0.003–5.3 mg/L	0.3 (SMCL)
	Manganese	0.1–0.05 mg/L	0.05 (SMCL)
	Molybdenum	0.001–0.051 mg/L	0.04 (HAL)
	Nickel	0.001–0.009 mg/L	0.1 (HAL)
	Selenium	0.003–0.022 mg/L	0.05 (MCL)
	Sulfide	Detected in 14/28 wells	
	Uranium	0.001–0.023 mg/L	2000 (MCL)
	Zinc	0.001–0.017 mg/L	2 (HAL)

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standard

Notes:
* Numbers in *italics* are estimates.
MCL = Maximum Contaminant Level set by EPA (2005).
μg/L = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
HAL = Health Advisory Level set by EPA (2005).

Nutrients

Dawson (2001b) presented evidence for movement of nitrate to shallow groundwater in the southeastern Sacramento Valley. Specifically, she demonstrated a significant correlation of nitrate concentrations to depth within the aquifer in oxygenated wells—higher nitrate concentrations were associated with shallower goundwater indicating movement of nitrate from land surface associated with agricultural activities (overlying land uses). There are naturally occurring nitrates in some formations of the Sacramento Valley, however, nitrate concentrations that occurred at concentrations above background levels are introduced into the groundwater via human activates (The NAQWA program set a threshold of 3mg/L of nitrate to indicate concentrations that are a at a level that is influenced by human activities) such as agriculture and urbanized development.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The predominant geochemical facies of the groundwater in the Colusa subbasin are calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. Two processes appear to primarily affect groundwater salinity in the Colusa subbasin: evaporation of irrigation water and shallow groundwater and mixing of naturally occurring saline groundwater (Hull 1984; Olmsted and Davis 1961; Dawson 2001a). Using isotope data, Dawson (2001a) presented evidence that partial evaporation as indicated by the isotope data accounted for some of the measured increase in salinity among shallow groundwater samples.

Pesticides

Rice pesticides Molinate, Thiobencarb and Carbofuran were detected in 7, 3, and 4 of the 28 wells sampled during the 1997 study by the USGS (Dawson 2001a). The most prevalent pesticide detected in groundwater was bentazon. Bentazon was used in rice fields until it was suspended in 1989 and officially banned in 1992. Its presence in groundwater in studies completed in 1997 (Domagalski et al. 2000) suggests it is readily transported in groundwater and does not degrade quickly. Detected pesticide concentrations were below state and federal drinking water standards in all occurrences.

Dawson (2001a) investigated the relationship between groundwater quality and rice cultivation land use practices in data collected during 1998. Dawson (2001a) found that shallower groundwater had more occurrences of pesticide contamination than deeper groundwater, indicating the movement of pesticides from the ground surface downward. Concentrations of bentazon showed a statistical relationship to tritium concentrations. Since tritium is used for age-dating groundwater, this relationship suggests that bentazon concentrations may be related to recharge age of the groundwater in which it was found. Tritium concentrations in all wells except one indicate that groundwater in the rice growing areas of the Colusa subbasin were recharged after 1950. Using trition dating and pesticide use information Dawson (2001a) estimated groundwater recharge date to be sometime in the late 1970s.

Irrigation practices can have an effect on the amount of pesticides that reach groundwater. Troiano et al. (1993) investigated different irrigation methods and found that "leaching of pesticides was less in sprinkler applications because water was applied more frequently in smaller applications than for the basin-flooding method. For basin-flooding treatments, as those practiced on rice fields, a large amount of water application was required for each irrigation in order to provide application across the plot. Although irrigations were less frequent, the larger water volume caused greater downward movement of water and atrazine residues."

Trace Elements

The chemistry of geology formations in the Colusa subbasin influences the concentrations of trace elements. Dawson (2001a) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and zinc. Concentrations of potassium were significantly lower in the western alluvial fans, which contain the Colusa subbasin. Concentrations of boron, chloride, fluoride, molybdenum, sulfate, and zinc were significantly higher in the western alluvial fans. Concentrations of arsenic were significantly higher in the central flood basins, which are also part of the Colusa subbasin. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Organic Carbon and DPBs

There is some evidence that recent changes in management practices in rice may result in higher dissolved organic carbon concentrations in deep percolation water (Dawson 2001a). High dissolved organic carbon content was confirmed in 43% of the wells studied by Dawson (2001a). The median concentration of which was 2.7 mg/L, much higher than the national median of 0.7 mg/L (Leenheer et al. 1974).

Corning Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Corning Subbasin is bounded on the west by the Coast Ranges, on the north by Thomes Creek, on the east by the Sacramento River, and on the south by Stony Creek. Stony Creek is believed to be a hydrologic boundary throughout the year. The Corning Subbasin is likely contiguous with the Red Bluff Subbasin at depth. The subbasin is 205,600 acres (321 square miles) in size and is located in parts of Tehama and Glenn Counties.

The following description of the hydrogeology in the Corning subbasin is taken from DWR Bulletin 118 (DWR 2004).

The Corning Subbasin aquifer system is comprised of deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and the Pleistocene terrace deposits of the Modesto and Riverbank Formations. The Tertiary deposits consist of the Pliocene Tehama and Tuscan Formations.

Holocene Stream Channel deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Tehama Formation and Quaternary stream terrace deposits. The thickness varies from 1 to 80 feet. The unit represents the upper part of the unconfined zone of the aquifer and is moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

The Pleistocene Modesto Formation consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tehama and the Riverbank Formations. The deposit ranges from less than 10 feet to nearly 200 feet across the valley floor. These terrace deposits are observed along Thomes Creek, Burch Creek, and Stony Creek.

The Pleistocene Riverbank Formation consists of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. The formation ranges from less than one foot to over 200 feet thick depending on location. Surficial deposits are observed over the eastern third of the subbasin and along Burch Creek and its tributaries.

The Pliocene Tehama Formation consists of sediments originating from the coastal mountains and is the primary source of groundwater for the subbasin. The formation ranges in thickness up to 2,000 feet, increasing in thickness from west to east, dipping 4 degrees to the east. The majority of the formation consists of fine-grained sediments indicative of deposition under floodplain conditions. The majority of both coarse and fine-grained sediments are unconsolidated or moderately consolidated.

The Pliocene Tuscan Formation is located within the eastern third of the subbasin. The formation occurs at a depth of approximately 200 feet from the surface and is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are believed to extend as far west as the Corning Canal.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B.

Sub-Areas of the Corning Subbasin

Sacramento Valley Floodplain

Pleistocene and Holocene silt, sand, and gravel deposits in the vicinity of the City of Corning extend to depths of 50–185 feet. The Tehama Formation near the City of Corning consists of yellow clay, poorly consolidated sandstone, and conglomerate.

Dissected Uplands

The surface of the upland area within the central third of the subbasin between Thomes Creek and Stony Creek includes a coarse-grained gravelly conglomerate locally capping the Tehama Formation. Wells drilled in this area encounter up to 60 feet of coarse deposits before reaching fine-grained Tehama deposits. The deposits are believed to be formed as a response to a fixed base level by impeded or enclosed drainages and have been referred to as the Red Bluff Formation. The shallow gravel is not a significant contributor to groundwater storage due to its position above the saturated zone.

Thomes Creek Floodplain

Bounding the northern extents of the subbasin, the Thomes Creek floodplain includes Holocene alluvium underlain by deposits of both the Modesto and Riverbank Formations. The floodplain averages about 1 mile in width and extends from the Coast Ranges to the Sacramento River floodplain.

Stony Creek Floodplain

The southern part of the subbasin, including the Capay plain, is alluviated by older floodplain deposits and channel deposits of Stony Creek. This area includes a moderately well-defined, highly productive, shallow water-bearing zone reaching a thickness of 150 feet along Stony Creek and 110 feet along the Sacramento River. Domestic and shallow irrigation wells along the west side of the Capay plain and south of the Tehama County line provide moderate-to-high yields from confined groundwater in 10–50-foot thicknesses of highly pervious pebble and cobble gravels. In the northwest part of Capay plain, older alluvium of the Riverbank Formation extends from the surface to 150 feet. Wells in this zone have low-to-moderate yields. This zone is underlain by a highly productive confined gravel averaging 40 feet in thickness.

Groundwater level data show seasonal fluctuations of approximately 3–15 feet for unconfined wells (5 feet near the Sacramento River), up to 30 feet for semi-confined wells away from the river, 5–20 feet for composite wells, and 10–30 feet for confined wells. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels. During the 1976–1977 and 1987–1994 droughts, there was a decline in groundwater levels of 5–12 feet, followed by a recovery to pre-drought conditions of the early 1970s and 1980s.

Groundwater storage capacity was estimated to be 2,753,000 acre-feet. This estimate was based on an average specific yield of 6.7% and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (19-25 inches/year), irrigation infiltration, and stream infiltration. The Tehama-Colusa Canal and Corning Canals intersect the basin. These canals, which are part of the Central Valley Project, serve to provide irrigation water to the member water user associations, including the Corning WD, which has jurisdiction in the Colusa Basin.

Estimate of groundwater extraction for agricultural use is estimated to be 152,000 acre-feet. Municipal and industrial use is approximately 6,600 acre-feet. Deep percolation of applied water is estimated to be 54,000 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 37% of the subbasin, urban land use accounts for about 4% of the subbasin, and native land accounts for about 59% of the subbasin. The primary crop types in the region are eucalyptus, olives, orchards, and pasture (Tehama County 2003). Table 4-12 provides details of the land uses within the subbasin.

Table 4-12. Land Use in the Corning Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	19,000	9.20
Deciduous Fruits and Nuts	19,500	9.50
Field Crops	2,900	1.40
Grain and Hay	10,500	5.10
Pasture	18,100	8.80
Rice	1,170	0.60
Truck, Nursery, and Berry Crops	750	0.40
Idle	1,950	0.90
Semiagricultural and Incidental	1,910	0.90
Subtotal	75,780	36.90
Urban		
Urban Landscape	40	0.02
Urban Residential	5,720	2.80
Commercial	390	0.20
Industrial	730	0.40
Vacant	1,970	1.00
Subtotal	8,850	4.30
Native		
Native Vegetation	108,900	53.00
Barren and Wasteland	2,580	2.60
Riparian	4,200	2.00
Water	5,250	2.60
Subtotal	120,930	58.80
Total	205,560	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Corning groundwater subbasin is within parts of the Shasta-Tehama and Colusa Watersheds. The public agencies within the Corning subbasin are: Tehama County Flood Control and Water Conservation District, Orland Unit Water Users' Association, Capay Rancho WD, City of Corning, Corning WD, Kirkwood WD, Richfield WD, Tehama WD, O’Connell MWD. City of Orland, Glenn Colusa ID, Thomes Creek WD. Tehama County adopted a groundwater management ordinance in 1994 and a countywide AB 3030 plan in 1996. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance are off-parcel groundwater use, and influence of well pumping restrictions. The city of Corning is located within the subbasin. This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. The subbasin has localized areas of calcium-bicarbonate waters near Stony Creek. TDS concentrations range from 130-to 490-mg/L, averaging 286 mg/L. The Corning Subbasin has locally high calcium. Groundwater quality problems in the Corning Subbasin due to irrigated agriculture could not be identified.

Two groundwater supply wells have been shut down and are being monitored by the City of Corning because of methyl tertiary butyl ether (MTBE) and perchloroethylene (PCE) concerns. Monitoring for water quality also occurs twice weekly at seven locations for bacterial and fecal coliform.

Dye Creek Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Dye Creek Subbasin is bounded on the southwest by the Sacramento River, on the northwest by Antelope Creek, on the east by the Chico Monocline, and on the south by Mill Creek. The subbasin is contiguous with the Antelope and Los Molinos subbasins at depth. The subbasin is 27,700 acres (43 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the South American subbasin is taken from DWR Bulletin 118 (DWR 2004).

The aquifer system is comprised of continental deposits of Tertiary to late Quaternary age. The Quaternary deposits include Holocene basin deposits and Pleistocene deposits of the Modesto and Riverbank Formations and Pleistocene fanglomerate. The Tertiary deposits include Pliocene Tehama and Tuscan formations.

Holocene basin deposits are exposed east of Highway 99, north and south of Dairyville, within the central portion of the subbasin. Basin deposits are the result of sediment-laden floodwaters rising above the natural levees of streams and rivers and spreading across low-lying areas. Thickness of the deposits has not been determined. The deposits generally have low permeability and yield low quantities of poor quality water to wells.

The Pleistocene Modesto Formation is observed along the western extents of the subbasin. The formation consists of undifferentiated terrace deposits of unconsolidated weathered and un-weathered gravel, sand, silt, and clay. Thickness of the unit can range from 0 to 150 feet.

The Pleistocene Riverbank Formation is exposed east of the Sacramento River north of Mill Creek. The formation is not a significant water-bearing formation due to its limited depth and areal extents.

Pleistocene Fanglomerate is observed along the eastern foothills and within the southern third of the subbasin. The formation is an alluvial fan deposit derived from erosion and deposition of volcanic mudflows of the Tuscan Formation and consists of polylithic volcanic clasts set in weathered tuffaceous matix. The fan deposits are poorly sorted and somewhat indurated to well cemented. Thickness of the fan deposits is up to 150 feet. The fanglomerate is not sufficiently thick to produce large quantities of groundwater.

The Pliocene Tuscan Formation is composed of a series of volcanic breccia, tuff, tuff breccia, volcanic sandstone and conglomerate, basalt flows, and tuffaceous silt and clay layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subbasin and extend in the subsurface west to the Sacramento River. Surface exposures of Unit D appear along the east side of the subbasin and east of the subbasin boundary. The subsurface extent of Unit D is unknown.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B. The Tuscan Formation reaches a thickness of 1,500 feet over older sedimentary deposits. The slope of the formation averages approximately 2.5 degrees, east of the valley, and steepens sharply to 10 to 20 degrees southwestward towards the valley at the Chico Monocline (Olmsted and Davis 1961). The formation flattens beneath valley sediments.

The Pliocene Tehama Formation consists of fluvial deposits of predominantly silt and clay with gravel and sand interbeds and occurs in the subsurface along the western boundary of the subbasin.

Long-term comparison of groundwater levels indicate a decline of 2 to 5 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of early 1970s and 1980s. Generally, groundwater level data show a seasonal fluctuation ranging from 2 to 10 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (17 inches/year), irrigation infiltration, stream infiltration, and subsurface flow. The main water source for irrigation is a mix of groundwater and surface water (Tehama County 2003). The Chico Monocline serves as a geographical boundary with some areas of recharge located east of the boundary.

Estimate of groundwater extraction for agricultural use is estimated to be 9,300 acre-feet. Municipal and industrial use is approximately 680 acre-feet. Deep percolation of applied water is estimated to be 3,200 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 23% of the subbasin, urban land use accounts for about 3% of the subbasin, and native land accounts for about 74% of the subbasin. The primary crop types in the region are orchards and pasture (Tehama County 2003). Table 4-13 provides details of the land uses within the subbasin.

Table 4-13. Land Use in the Dye Creek Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	2,400	8.70
Field Crops	30	0.10
Grain and Hay	10	0.04
Pasture	3,160	11.40
Idle	530	1.90
Semiagricultural and Incidental	240	0.90
Subtotal	6,370	23.00
Urban		
Urban Landscape	20	0.04
Urban Residential	580	2.10
Commercial	10	0.04
Industrial	120	0.40
Vacant	180	0.70
Subtotal	910	3.30
Native		
Native Vegetation	18,900	68.30
Barren and Wasteland	80	0.30
Riparian	1,060	3.80
Water	360	1.30
Subtotal	20,400	73.70
Total	**27,680**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Dye Creek groundwater subbasin is within the Shasta-Tehama Watershed. The only public agencies within the subbasin are the Tehama County Flood Control and Water Conservation District. Tehama County adopted an AB 3030 groundwater management plan in 1996. There are no major urban areas within the subbasin. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use and influence of well pumping restrictions. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater in the Dye Creek subbasin is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. TDS ranges from 119 to 558 mg/L, averaging 280 mg/L. The DPR verified detections of five pesticides in Tehama County between 1985 and 2003. There were 14 detections total: 1 detection of ACET, 7 detections of atrazine, 2 detections of DEA, 1 detection of diuron, and 3 detections of simizine.

East Butte Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The East Butte Subbasin is bounded on the west and northwest by Butte Creek, on the northeast by the Cascade Ranges, on the southeast by the Feather River and the south by the Sutter Buttes. The subbasin is 265,400 acres (415 square miles) in size and is located in parts of Butte and Sutter Counties.

The following description of the hydrogeology in the East Butte subbasin is taken from DWR Bulletin 118 (DWR 2004).

The East Butte aquifer system is comprised of deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene stream channel deposits and basin deposits, Pleistocene deposits of the Modesto and Riverbank Formations, and Sutter Buttes Alluvium. The Tertiary deposits include the Tuscan and Laguna Formations.

Holocene Stream Channel deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Quaternary stream terrace alluvial deposits. The thickness varies from 1 to 80 feet. These deposits represent the upper part of the unconfined zone of the aquifer and are moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

Holocene Basin deposits are the result of sediment-laden floodwaters that rose above the natural levees of streams and rivers to spread across low-lying areas. They consist primarily of silts and clays and may be locally interbedded with stream channel deposits. These deposits result from deposition from erosion from portions of the Cascade Ranges to the Sutter Buttes. Thicknesses of the deposits range to 150 feet (DWR 2000). These deposits have low permeability and generally yield low quantities of poor quality water to wells.

The Pleistocene Modesto Formation in this subbasin consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tuscan Formation, Laguna Formation, and the Riverbank Formation. Surface exposure of the formation is west of the Feather River extending from south of the Thermalito Afterbay to the southern subbasin boundary. The formation may extend across the entire subbasin, underlying basin deposits, with thicknesses ranging from 50 to 150 feet.

The Pleistocene Riverbank Formation is older terrace deposits that consist of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. Surface exposure of the Riverbank Formation is primarily south and west of the Thermalito Afterbay. The formation may extend across the entire subbasin, underlying basin and Modesto deposits, with thicknesses ranging from 50 to 200 feet.

In the southern portion of the subbasin, alluvium of the Sutter Buttes is observed in the subsurface and may range in thickness up to 600 feet. The fan deposits forming the apron around the buttes consist largely of gravel, sand, silt, and clay and may extend up to 15 miles north of the Sutter Buttes and westerly beyond the Sacramento River. Utility pump test records show the average well yield for that formation to be approximately 2,300 gallons per minute (gpm) with an average specific capacity of 64.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. Thickness of the formation is estimated to be 800 feet. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subsurface in the northern part of the subbasin and Units A and B are found in the southern part of the subbasin. Surface exposures of Units B and C are located in the foothills at the far eastern extents of the subbasin.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B.

The Pliocene Laguna Formation consists of interbedded alluvial sand, gravel, and silt deposits that are moderately consolidated and poorly-to-well cemented. The Laguna Formation is compacted and generally has a low-to-moderate permeability, except in scattered gravels in the upper portion. The formation yields moderate quantities of water to wells along the eastern margin of the valley. Wells of higher capacity generally tap underlying Tuscan deposits.

Surface exposures of the Laguna appear along the eastern margin of the subbasin in the vicinity of the Thermalito Afterbay and extend westerly in the subsurface. The lateral extent of the formation is unknown. The thickness of the formation is difficult to determine because the base of the unit is rarely exposed. Estimates of maximum thickness range from 180 to 1,000 feet. Geologic cross sections developed by DWR estimate the thickness to be approximately 500 feet. Wells completed in the formation yield only moderate quantities of water.

Wide seasonal fluctuations in groundwater levels exist in the northern part of the subbasin. Composite well fluctuations average about 15 feet during normal years and 30–40 feet during drought years. Annual groundwater fluctuations in the confined and semi-confined aquifer system range from 15 to 30 feet during normal years. In the part of the subbasin located within the southern part of Butte County, groundwater level fluctuations for composite wells average about 4 feet during normal years and up to 10 feet during drought years. The groundwater fluctuations for wells constructed in the confined and semiconfined aquifer system average 4 feet during normal years and up to 5 feet during drought years. Groundwater flows primarily to the southwest towards the West Butte subbasin and the Sacramento River.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (18–27 inches/year), subsurface flow, irrigation infiltration, and stream infiltration. The northeast boundary along the Cascade Ranges is primarily a geographic boundary with some groundwater recharge occurring beyond that boundary. Localized fluctuations in groundwater levels observed just south of the Thermalito Afterbay are due to the recharging of groundwater from this surface water system.

Estimates of groundwater extraction for agricultural; municipal and industrial; and environmental wetland uses are 104,000, 75,500, and 1,300 acre-feet respectively. Deep percolation of applied water is estimated to be 126,000 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1995 (Yuba County and 1999 (Butte County). Agricultural land use accounts for about 62% of the subbasin, urban land use accounts for about 4% of the subbasin, and native land accounts for about 35% of the subbasin. Table 4-14 provides details of the land uses within the subbasin.

Table 4-14. Land Use in the East Butte Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	2,470	0.90
Deciduous Fruits and Nuts	35,400	13.30
Field Crops	3,130	1.20
Grain and Hay	1,660	0.60
Pasture	6,810	2.60
Rice	110,000	41.40
Truck, Nursery, and Berry Crops	480	0.20
Vineyards	97	0.04
Idle	3,000	1.10
Semiagricultural and Incidental	1,480	0.60
Subtotal	164,500	61.90
Urban		
Urban—unclassified	4,260	1.60
Urban Landscape	560	0.20
Urban Residential	1,690	0.60
Industrial	1,290	0.50
Vacant	1,400	0.50
Subtotal	9,520	3.60
Native		
Native Vegetation	59,500	22.40
Barren and Wasteland	3,130	1.20
Riparian	22,900	8.60
Water	6,350	2.40

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	91,880	34.60
Total	**265,900**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The East Butte groundwater subbasin is within the Butte-Sutter-Yuba Watershed. The public agencies within the East Butte subbasin are: Butte Basin Water Users Association, Biggs-West Gridley WD, Butte WD, Durham ID, City of Biggs, City of Gridley, Oroville-Wyandotte ID, Richvale ID, Thermalito ID, and Western Canal WD. The North Burbank Public Utility District is a private water agency in the East Butte subbasin. Butte County adopted a groundwater management ordinance in 1996. The Butte County ordinance requires export permits for groundwater extraction and substitute pumping, establishes the Water Commission and Technical Advisory Committee, and provides countywide groundwater monitoring programs. The city of Oroville is the largest urban area within the subbasin. This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate waters are the predominant groundwater water types in the subbasin. Magnesium bicarbonate waters occur locally near Biggs-Gridley, south and east to the Feather River. TDS ranges from 122 to 570 mg/L, averaging 235 mg/L. Localized high concentrations of manganese, iron, magnesium, TDS, conductivity, ASAR, and calcium occur within the subbasin. There is evidence of groundwater pesticide contamination in Butte County (DPR 2003); triazine herbicides and degradation productions, diuron, bromocil, norflurazon, and bentazon were detected in wells in Butte County. Data for the locations of detections could not be obtained.

Los Molinos Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Los Molinos Subbasin is bounded on the west by the Sacramento River, on the north by Mill Creek, on the east by the Chico Monocline, and on the south by Deer Creek. Mill Creek and Deer Creek serve as hydrologic boundaries in the near surface. The subbasin is hydrologically contiguous with Dye Creek and Vina subbasins at depth. The subbasin is 33,200 acres (52 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Los Molinos subbasin is taken from DWR Bulletin 118 (DWR 2004).

The aquifer system of the subbasin is comprised of continental deposits of late Quaternary to Tertiary age. The Quaternary deposits include Holocene stream channel deposits, Pleistocene Modesto Formation terrace deposits located along most stream and river channels, and Pleistocene fanglomerate deposits from the Cascade Range. The Tertiary deposits include the Tuscan Formation.

The western edge of the subbasin is bounded by Holocene stream channel deposits of the Sacramento River. These deposits consist of moderately to highly permeable unconsolidated gravel, sand, silt and clay derived from the erosion, reworking, and deposition of the adjacent Tuscan and Tehama Formations. The thickness varies from 1 to 80 feet. The unit represents the upper part of the unconfined zone of the aquifer and is moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

Pleistocene Modesto Formation deposits extend from Mill Creek to Deer Creek on the west side of the subbasin and along the courses of Mill Creek, Deer Creek, and Thomes Creek. The formation consists of undifferentiated terrace deposits of unconsolidated weathered and un-weathered gravel, sand, silt, and clay. Thickness of the unit can range from 0 to 150 feet.

Along with the Modesto Formation, the Pleistocene Fanglomerate is a primary surficial deposit in the subbasin. The formation is an alluvial fan deposit derived from erosion and deposition of volcanic material from mudflows of the Tuscan Formation and consists of polylithic volcanic clasts set in a weathered tuffaceous matix. The fan deposits are poorly sorted and somewhat indurated to well cemented. The fanglomerate is being dissected by Mill Creek and Deer Creek. Thickness of the deposit is up to 150 feet. The fanglomerate is not sufficiently thick to produce large quantities of groundwater.

The Pliocene Tuscan Formation is the primary source of groundwater in the subbasin. The formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subbasin and extend in the subsurface west of the Sacramento River.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick confining layers for groundwater contained in the more permeable sediments of Unit B.

The Tuscan Formation reaches a thickness of 1,500 feet over older sedimentary deposits. The dip of the formation averages approximately 2.5 degrees, east of the valley, and steepens sharply to 10–20 degrees southwestward towards the valley at the Chico Monocline. The formation flattens beneath valley sediments.

Long-term comparison of groundwater levels indicates a slight decline associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Generally, groundwater level data show an average seasonal fluctuation of approximate 2 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in groundwater levels.

Groundwater storage capacity was estimated to be 397,700 acre-feet. This estimate was based on an average specific yield of 6.0% and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (18 inches/year), irrigation infiltration, stream infiltration, and subsurface flow. The major source for irrigation water is a mix of groundwater and surface water (Tehama County 2003). The Chico Monocline serves as a geographical boundary with some areas of recharge located east of the boundary.

Estimate of groundwater extraction for agricultural use is estimated to be 5,900 acre-feet. Municipal and industrial use is approximately 1,000 acre-feet. Deep percolation of applied water is estimated to be 3,000 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 62% of the subbasin, urban land use accounts for about 4% of the subbasin, and native land accounts for about 35% of the subbasin. The primary crop types are orchards and pasture (Tehama County 2003). Table 4-15 provides details of the land uses within the subbasin.

Table 4-15. Land Use in the Los Molinos Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	3,380	10.20
Field Crops	110	0.30
Grain and Hay	190	0.60
Pasture	2,180	6.60
Idle	180	0.50
Semiagricultural and Incidental	110	0.30
Subtotal	6,150	18.50
Urban		
Urban Landscape	40	0.10
Urban Residential	510	1.50
Commercial	60	0.20
Industrial	140	0.40
Vacant	140	0.40
Subtotal	890	2.70
Native		
Native Vegetation	23,400	70.50
Barren and Wasteland	460	1.40
Riparian	1,700	5.10
Water	600	1.80
Subtotal	26,160	78.80
Total	**33,200**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Los Molinos groundwater subbasin is within the Shasta-Tehama Watershed. The public agencies within the subbasin are: Tehama County Flood Control and Water Conservation District, Stanford Vina Ranch ID, Los Molinos Mutual Water Co., Los Molinos Water Works. Tehama County Flood Control and Water Conservation District adopted an AB 3030 groundwater management plan in 1996. There are no major urban areas within the subbasin. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use and influence of well pumping restrictions. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater in the Los Molinos subbasin is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. TDS ranges from 119 to 558 mg/L, averaging 280 mg/L.

Los Molinos Community Service District (CSD) provides water to the town of Los Molinos. The primary water supply well (650 feet deep, open from 550 to 650 feet) produces water with about 10 parts per million (ppm) of arsenic (County of Tehama 2003). The current U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) for arsenic is 50 mg/L; however, lower MCL for arsenic (0.005 mg/L or 0.010 mg/L) have been proposed (Dawson 2001a, EPA 2005).

North American Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The North American groundwater subbasin is bounded by the Sierra Nevada foothills on the east, the Feather and Sacramento Rivers on the west, the Sacramento and American Rivers on the south, and the Bear River on the north. The subbasin is about 548 square miles in size and is located in parts of Sutter, Placer, and Sacramento Counties.

The following description of the hydrogeology in the South American subbasin is taken from DWR Bulletin 118 (DWR 2004).

The eastern boundary represents the approximate edge of the alluvial basin, where little or no groundwater flows into or out of the groundwater basin from the rock of the Sierra Nevada. The eastern portion of the study area is characterized by low rolling dissected uplands. The western portion is nearly a flat flood basin for the Bear, Feather, Sacramento, and American rivers, and several small east side tributaries.

The water-bearing materials of the North American subbasin are dominated by unconsolidated continental deposits of Late Tertiary and Quaternary age. Deposits include Miocene/Pliocene volcanics, older alluvium, and younger alluvium. The alluvium can be characterized as comprising the upper aquifer system, occupying the upper 200–300 feet below ground surface. The Mehrten and older geologic units can be characterized as comprising the lower aquifer system, occurring generally deeper than 300 feet towards the west side of the subbasin. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 2,000 feet along the western margin of the subbasin. Most of the groundwater is produced in the northern portion of the subbasin. The aquifer zones in the upper 200–300 feet of this portion of the subbasin appear to be unconfined and behave similarly to stresses imposed on them. Conversely, deeper zones show a delayed response to stresses in the upper zone, indicating possibly limited interconnection with the shallower zones.

The younger alluvium deposits include flood basin deposits and recent stream channel deposits. The flood basin deposits occur along the western margin of the subbasin adjacent to the Sacramento River. The flood basin deposits consist primarily of silts and clays, although they may be locally interbedded with stream channel deposits of the Sacramento River. Thickness of the unit ranges from 0 to 100 feet. These fine-grained flood basin deposits have low permeability and generally yield low quantities of water to wells. Brackish water is often encountered in these deposits. The stream channel deposits include sediments deposited in the channels of active streams as well as overbank deposits of those streams, terraces, and local dredge tailings. These deposits occur predominantly along the Sacramento and American Rivers and their major tributaries, and consist primarily of unconsolidated silt, fine- to medium-grained sand, and gravel. Thickness of the unit ranges from 0 to about 100 feet. Sand and gravel zones in the younger alluvium are highly permeable and yield significant quantities of water to wells.

The older alluvium deposits consist of loosely to moderately compacted sand, silt, and gravel deposited in alluvial fans during the Pliocene and Pleistocene. A number of formational names have been assigned to the older alluvium, including the Modesto, Riverbank, Turlock Lake, Victor, Laguna and Fair Oaks Formations, and the Arroyo Seco and South Fork Gravels. The older alluvial units are widely exposed between the Sierra Nevada foothills and overlying younger alluvial units near the axis of the Sacramento Valley. Thickness of the older alluvium ranges between 100 and 650 feet. It is moderately permeable.

The Miocene/Pliocene volcanic deposits consist of the Mehrten Formation, a sequence of fragmented volcanic rocks. The Mehrten Formation is exposed along the eastern margin of the subbasin between the towns of Lincoln and Folsom. It is composed of intervals of “black sands,” stream gravels, silt, and clay interbedded with intervals of dense tuff breccia. The sand and gravel intervals are highly permeable and wells completed in them have reported yields of over 1,000 gpm. The tuff breccia intervals act as confining layers. Thickness of the unit is between 200 and 1,200 feet.

Groundwater levels in southwestern Placer County and northern Sacramento County have generally decreased for the last 40 years or more. Groundwater levels in Sutter and northern Placer Counties generally have remained stable, although some wells in southern Sutter County have experienced declines.

DWR (2004) used and estimated specific yield of 7% and depth of 200 feet to calculate a storage capacity of 4.9 maf.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (18–20 inches/yr in the west, 20–24 inches/yr in the east), irrigation infiltration, and stream infiltration. Groundwater discharge likely occurs as evapotranspiration, subsurface flow, stream discharge, and pumpage. DWR estimated the groundwater budget components for a 1990 level of development. Estimated inflows include natural recharge at 83,800 acre-feet and applied water recharge at 29,800 acre-feet. Estimated outflows include urban pumpage at 109,900 acre-feet and agricultural pumpage at 289,100 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1994 (Placer County), 1998 (Sutter County), and 2000 (Sacramento County). Agricultural land use accounts for about 42% of the subbasin, urban land use accounts for about 29% of the subbasin, and native land accounts for about 29% of the subbasin. Table 4-16 provides details of the land uses within the subbasin.

Table 4-16. Land Use in the North American Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	200	0.10
Deciduous Fruits and Nuts	9,680	2.80
Field Crops	12,400	3.60
Grain and Hay	15,200	4.50
Pasture	15,300	4.50
Rice	74,100	21.80
Truck, Nursery, and Berry Crops	1,230	0.40
Vineyards	50	0.01
Idle	11,900	3.50
Semiagricultural and Incidental	2,070	0.60
Subtotal	142,130	41.80
Urban		
Urban—unclassified	76,300	22.40
Urban Landscape	3,710	0.20
Urban Residential	5,210	1.50
Industrial	3,810	1.10
Commercial	660	0.20
Vacant	10,800	3.20
Subtotal	100,490	28.70
Native		
Native Vegetation	90,200	26.50
Barren and Wasteland	290	0.10
Riparian	4,360	1.30
Water	2,860	0.80
Subtotal	97,710	29.50
Total	**340,330**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The North American groundwater subbasin is within the Placer North Sacramento Watershed.

The public agencies within the North American subbasin are: South Sutter WD, Camp Far West ID, Rio Linda/Elverta CWD, Citrus Heights WD, San Juan Suburban WD, Fair Oaks WD, Carmichael WD, Sacramento Suburban WD, Western Placer ID, Placer County WA, Del Paso Manor WD, City of Sacramento WSA, City of Roseville, Sacramento County Water Agency (DWR 2004).

The public agencies within the North American subbasin are Pleasant Grove—Verona MWC, Natomas Central MWC, California-American WC, Orangevale WC, Southern California WC.

The Sacramento Groundwater Authority (SGA) is a joint powers authority formed to manage the North Area Groundwater Basin, which is in the southern part of the North American subbasin. The Regional Water Authority (RWA) is a joint powers authority that serves and represents the interests of 21 water providers in the greater Sacramento, Placer, and El Dorado County region.

The Sacramento Groundwater Authority adopted a groundwater management plan on December 11, 2003. South Sutter WD adopted an AB 3030 plan in 1995. Placer County Water Agency adopted an AB 3030 plan in 1998. City of Lincoln adopted a groundwater management plan on November 12, 2003.

The Sacramento Metropolitan urban is partly located within the subbasin including the cities of Sacramento, Roseville, Citrus Heights, and Lincoln.

This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

Many areas of good quality groundwater exist in the North American subbasin. However, in some parts of the basin groundwater quality is marginal. The three major groundwater types are: magnesium calcium bicarbonate or calcium magnesium bicarbonate; magnesium sodium bicarbonate or sodium magnesium bicarbonate; and sodium calcium bicarbonate or calcium sodium bicarbonate.

Comparison of groundwater quality data with applicable water quality standards and guidelines for drinking and irrigation indicate elevated levels of TDS, chloride, sodium, bicarbonate, boron, fluoride, nitrate, iron, manganese, and arsenic may be of concern in some locations within the subbasin.

High TDS levels exist in an area along the Sacramento River extending from Sacramento International Airport northward to the Bear River. The highest levels of TDS are found in an area extending just south of Nicholas to Verona, between RD 1001 and the Sutter Bypass. Some wells in this area have reported TDS exceeding 1,000 mg/L.

This same area along the Sacramento River extending from Sacramento International Airport northward to the Bear River also contains high levels of chloride, sodium, bicarbonate, manganese, and arsenic. The groundwater in the southern part of the basin is generally characterized as good quality, low in disinfection by-product precursor materials and moderate in mineral content, although some localized contamination issues do exist.

Nutrients

Dawson (2001b) presented evidence for movement of nitrate to shallow groundwater in the southeastern Sacramento Valley. Specifically, she demonstrated a significant correlation of nitrate concentrations to depth within the aquifer in oxygenated wells—higher nitrate concentrations were associated with shallower goundwater indicating movement of nitrate from land surface associated with agricultural activities (overlying land uses). There are naturally occurring nitrates in some formations of the Sacramento Valley, however, nitrate concentrations that occurred at concentrations above background levels are introduced into the groundwater via human activates (The NAQWA program set a threshold of 3mg/L of nitrate to indicate concentrations that are a at a level that is influenced by human activities) such as agriculture and urbanized development. At this time, the data available for the Southeastern Sacramento Valley, an area that includes the North American subbasin, show that 8 of the 31 wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L. The median concentration for nitrate in this study was 1.4 mg/L, which is higher than the national median (1.0 mg/L) for drinking water aquifers.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The groundwater in the North American subbasin was classified as multiple geochemical facies: magnesium calcium bicarbonate or calcium magnesium bicarbonate; magnesium sodium bicarbonate or sodium magnesium bicarbonate; and sodium calcium bicarbonate or calcium sodium bicarbonate.

Two processes appear to primarily affect groundwater salinity in the North American subbasin. The first is evaporation of irrigation water and shallow groundwater. The second is mixing of naturally occurring groundwater (Hull 1984; Olmsted and Davis 1961; Dawson 2001a). Using isotope data, Dawson (2001a) presented evidence that partial evaporation accounted for some of the measured increase in salinity among shallow groundwater samples.

Pesticides

Pesticides were detected in four wells that affect the North American subbasin (Dawson 2001b). Three wells are located in the subbasin and one well is located in the South American subbasin but contamination is known to be moving across the American river to the North American subbasin. All concentrations were below the drinking water limits.

The most common pesticides detected in Dawson’s (2001b) 1996 study of the Southeastern Sacramento Valley were bentazon, simazine, atrazine, bromacil, and tebuthiuron were detected. The major uses for atrazine, bromacil, and tebuthiuron are for weed control in right-of-way areas and for landscape maintenance. Simazine is used for weed control in right-of-way areas and for landscape maintenance, and on many crops grown in the study area, including nut and fruit orchards.

Trace Elements

The chemistry of geology formations in the North American subbasin influences the concentrations of trace elements. Dawson (2001a) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and zinc. Concentrations of silica were significantly higher in the eastern alluvial plain, which contains the North American subbasin. The eastern alluvial plains showed higher concentration of arsenic than in the western alluvial plain. However she also presented evidence (Dawson 2001b) that, within the Southeastern Sacramento Valley, the concentration of arsenic is related to the dissolved oxygen concentration (or redox condition) of the groundwater. She found that as the concentration of dissolved oxygen increases, the arsenic concentrations decrease. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Organic Carbon and DPBs

Twenty-two percent of the North American subbasin is utilized as rice fields. Since 1983 rice farmers have been required to hold or recirculate irrigation water for up to 30 days after pesticide application to allow for the pesticides to degrade or volatilize out of the water (Dawson 2001a). There is evidence that this changes in management practice in rice cultivation may result in higher dissolved organic carbon concentrations in water that reaches the groundwater via deep percolation or irrigation water (Dawson 2001a). High dissolved organic carbon content was confirmed in 43% of the wells in rice growing areas studied by Dawson (2001a). The median concentration of which was 2.7 mg/L, much higher than the national median of 0.7 mg/L (Leenheer et al. 1974).

Volatile Organic Compounds

VOCs have many different uses including pesticides gasoline, degreasers, solvents, and refrigerants. Some VOCs are byproducts of the chlorination of drinking water. VOCs were detected in four of the ten wells in the North American subbasin in the 1996 study of the Southeastern Sacramento Valley by Dawson (2001b). The VOCs found in the wells are consistent with the land use surrounding each well. Those detected in agricultural areas were VOCs found in pesticides or gasoline while those detected in urban areas were VOCs associated with landscape maintenance, pet control, right-of-way weed control, gasoline, industrial chemicals and chlorinated drinking water.

North Yuba Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The North Yuba subbasin is bounded on the north by Honcut Creek, the Feather River on the west, on the south by the Yuba River, and on the east by the Sierra Nevada. The subbasin is about 55,900 acres (87 square miles) and is located entirely within Yuba County.

The following description of the hydrogeology in the South American subbasin is taken from DWR Bulletin 118 (DWR 2004).

The North Yuba subbasin aquifer system is comprised of continental deposits of Quaternary to Late Tertiary (Pliocene) age. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 1,000 feet along the western margin of the basin.

Dredger tailing deposits occur along the Feather River in the northwest and the Yuba River in the southeast of subbasin. The coarse gravels and cobbles can be up to 125 feet thick and are highly permeable. Stream channel and floodplain materials occur as coarse sand and gravels along present stream channels of the Yuba River, Feather River, and Honcut Creek. Coarser grained materials occur near streams with thicknesses up to 110 feet. Both grain size and thickness decrease with increased distance from streams. These deposits are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Well yields are reported in the range of 2,000 to 4,000 gpm.

The Pleistocene Victor Formation lies unconformably above the Laguna Formation. The majority of the formation occurs as alluvium throughout the subbasin, but floodplain deposits are present along stream channels above the alluvium.

Pleistocene Floodplain deposits occur as gravelly sand, silt, and clay from flood events along the Feather River and its tributaries. This unit overlies the Older Alluvium, underlies Quaternary Deposits, and ranges in thickness from 5 to 15 feet. These deposits provide a good medium for groundwater recharge, provided the groundwater can pass the lower contact with the Older Alluvium.

Pleistocene Alluvium occurs over more than 50% of the basin surface and at least 60% of its irrigated agricultural lands. Its thickness is highly variable due to its lower contact with the Laguna Formation. The Older Alluvium is comprised of Sierran alluvial fan deposits of loosely compacted silt, sand, and gravel with lesser amounts of clay deposits. The deposits occur as lenticular beds with decreasing thickness and grain size with increasing distance from the Yuba River and the foothills. Hardpan and claypan soils have developed to form an impermeable surface, but below this the Older Alluvium is moderately permeable and provides for most of the groundwater from domestic and shallow irrigation wells. Wells in the older alluvium have yields up to 1,000 gpm.

The Pliocene Laguna Formation is the most extensive water-bearing unit within the subbasin. The formation is comprised of reddish to yellowish or brown silt to sandy silt with abundant clay and minor lenticular gravel beds. It overlies the Mehrten Formation and occurs at the surface intermittently at the east end of the basin. The continental deposits of the Laguna Formation dip to the west beneath the Victor Formation and range in thickness from 400 feet near the Yuba River up to 1,000 feet in the southwest portion of the county. Although the occurrence of thin sand and gravel zones is common, many of them have reduced permeability due to cementation. This, coupled with its fine-grained character, leads to an overall low permeability for the Laguna Formation. Most of the groundwater produced from wells in the Laguna comes from overlying units.

The Miocene-Pliocene Mehrten Formation is a sequence of volcanic rocks of late Miocene through middle Pliocene age. Surficial exposures are limited to a few square miles in the northeast corner of the basin and thickness varies from 200 feet near the eastern margin of the basin to 500 feet near the Feather River. The Mehrten Formation is composed of two distinct units. One unit occurs as intervals of gray to black, well-sorted fluvial andesitic sand (up to 20 feet thick), with andesitic stream gravel lenses and brown to blue clay and silt beds. These sand intervals are highly permeable and wells completed in them can produce high yields. The second unit is an andesitic tuff-breccia that acts as a confining layer between sand intervals.

From 1950 through 1990, average basin groundwater levels remained relatively constant. Based on an analysis of hydrographs the Yuba River and Feather Rivers create a groundwater divide, which act as flow barriers in the shallow subsurface.

Groundwater storage capacity was estimated to be 620,000 acre-feet. This estimate was based on an area of 49,800 acres, an average specific yield of 6.9%, and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (20 inches/year in the southeast to 32 inches/yr in the northeast), irrigation infiltration, and stream infiltration. Stream channel and floodplain deposits present along the Yuba River, Feather River, and Honcut Creek are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Forty percent of the North Yuba subbasin is used for rice cultivation where the fields are typically flooded for 6 months each year, resulting in percolation of partially evaporated irrigation water.

Previous DWR unpublished studies have estimated natural and applied recharge. DWR has also estimated urban and agriculture extractions and subsurface outflow. Inflows include natural recharge of 51,100 acre-feet and applied recharge of 13,900 acre-feet. Groundwater discharge occurs as evapotranspiration, and pumpage. Outflows include urban extraction of 9,000 acre-feet, agricultural extraction of 65,800 acre-feet, and subsurface outflow of 21,800 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 75% of the subbasin, urban land use accounts for about 5% of the subbasin, and native land accounts for about 20% of the subbasin. Table 4-17 provides details of the land uses within the subbasin.

Table 4-17. Land Use in the North Yuba Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	390	0.70
Deciduous Fruits and Nuts	15,100	27.20
Field Crops	230	0.40
Grain and Hay	150	0.30
Pasture	1,760	3.20
Rice	22,000	39.60
Truck, Nursery, and Berry Crops	16	0.03
Idle	1,340	2.40
Semiagricultural and Incidental	410	0.70
Subtotal	41,400	74.50
Urban		
Urban—unclassified	1,900	3.40
Urban Landscape	88	0.20
Urban Residential	480	0.90
Industrial	120	0.20
Vacant	420	0.80
Subtotal	3,000	5.40

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	7,010	12.60
Barren and Wasteland	1,020	1.80
Riparian	2,150	3.90
Water	1,010	1.80
Subtotal	11,200	20.10
Total	**55,600**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The North Yuba groundwater subbasin is within the Butte-Sutter-Yuba Watershed.

The public agencies within the North Yuba subbasin are: Yuba County Water Agency, Ramirez Water District, Cordua Irrigation District.

In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. The Cordua Irrigation District and the Yuba County Water Agency have AB 3030 groundwater management plans.

The city of Marysville is located within the subbasin Yuba City is located at the southwestern boundary of the subbasin.

This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

The generally good water quality characteristics are apparent in the overall salinity of groundwater in the subbasin. In general, TDS concentrations in the subbasin are below 500 mg/L throughout the entire basin. DWR maintains data for 35 water quality wells in the North Yuba Subbasin. Data collected from these wells indicate a TDS range of 149 to 655 mg/L and a median of 277 mg/L. The primary water chemistry in the area indicates calcium magnesium bicarbonate or magnesium calcium bicarbonate groundwater. Some magnesium bicarbonate can be found in the northwest portion of the basin.

Groundwater Quality issues in the North Yuba subbasin include excess nutrients, trace elements, salinity and pesticides. Pesticides are persistent in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring but some are elevated to levels above the national limits. Elevated nitrates are possibly due to on-site sewage systems (PMC 1996). However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the North Yuba subbasin. Tables 4-18 and 4-19 summarize the available data.

Table 4-18. Water Quality in the North Yuba Subbasin

Constituent of Concern	Available Information about Groundwater Concentrations for North Yuba Subbasin
Nutrients	Median nitrate concentrations for the southeastern Sacramento Valley, including North Yuba subbasin was 1.4 mg/L. Only one well in the study area exceeded drinking water standards.
Pesticides (insecticides and herbicides) and degradation products	DPR verified bentazon detection in 10 wells with in Yuba County from 1996 to 2003 and one detection of benzol from July 2003 to June 2004. Pesticides detected in one domestic well in 1996 study, but concentration was below drinking water standards.
Salt—primarily as electrical conductivity and total dissolved solids.	
Trace elements	High concentration of arsenic (naturally occurring) in some areas.
Organic carbon and disinfection byproduct precursors	No available data.
Microorganisms	No available data.
Volatile organic compounds	VOCs were detected in 3 of the 4 wells in or near North Yuba subbasin. Concentrations below drinking water standards.

Notes:
mg/L = milligrams per liter.
Sources: Dawson 2001b, DPR 2004b.

Table 4-19. Concentrations of Constituents of Concern Detected in the Southeastern Sacramento Valley Aquifers (Includes the North Yuba Subbasin)

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
Nutrients	Nitrate—Ammonia as N	0.02–0.11 mg/L	30 (HAL)
	Nitrate as N	0.06–12 mg/L	10 (MCL[a])
	Nitrite as N	0.01–0.01 mg/L	1 (MCL[a])
	Orthophosphate, as P	0.03–0.4 mg/L	
	Phosphorus, as P	0.03–0.45 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	0.001–0.001 µg/L	3 (MCL[a])
	Bentazon	0.02–1.3 µg/L	18 (MCL[b])
	Bromacil	0.34 µg/L (one detection)	90 (HAL)
	Desethyl atrazine	0.004–0.044 µg/L	
	Simazine	0.006–0.077 µg/L	4 (MCL[a])
	Tebuthiuron	0.32 µg/L (one detection)	500 (HAL)
Salt—primarily as electrical conductivity and total dissolved solids.		149 to 655 mg/L, median is 277 mg/L (DWR 2004) 134–1,750 mg/L, median is 258 mg/L	500 (SMCL)
Inorganic Constituents			EPA Standard, 2000
	Arsenic	1–46 µg/L	50 (MCL[a])
	Bicarbonate	67–413 mg/L	

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
	Boron	12–110 µg/L	600 (HAL)
	Bromide	0.02–12 mg/L	
	Calcium	10–210 mg/L	
	Chloride	2.0–620 mg/L	250 (SMCL)
	Fluoride	0.1–0.3 µg/L	4 (MCL[a])
	Iron Fe	3–1,600 µg/L	300 (SMCL)
	Magnesium	5.0–100 mg/L	
	Manganese	1–870 µg/L	50 (SMCL)
	Potassium	0.40–4.1 mg/L	
	Silica	24–86 mg/L	
	Sodium	5.7–120 mg/L	
	Sulfate	1.0–130 mg/L	250 (SMCL)
	Total Hardness as $CaCO_3$	48 (soft)–940 (very hard) mg/L, median is 135 mg/L	
Organic carbon and disinfection byproduct precursors	DOC	0.2–0.7 mg/L, median 0.3 mg/L	
Volatile organic compounds*	1,1-Dichloroethane	*0.02*–0.04 µg/L	
	1,2,4-Trimethylbenzene	*0.01*–0.02 µg/L	
	1,2-Dichloroethane	0.19 µg/L	0.5 (MCL[a])
	Bromodichloromethane	*0.03* µg/L	100 (MCL[a])
	cis-1,2-Dichloroethene	0.43 µg/L	6 (MCL[b])
	Dichlorodifluoromethane	*0.04*–0.29 µg/L	1000 (HAL)
	Methyl tert-butyl ether	*0.06* µg/L	20 (HAL)
	Styrene	*0.06* µg/L	100 (MCL[a])
	Tetrachloroethene	0.58–0.97 µg/L	5 (MCL[a])
	Tetrachloromethane	1.2 µg/L	0.5 (MCL[b])
	Trichloroethene	*0.01*–5.5 µg/L	5 (MCL[a])
	Trichlorofluoromethane	*0.04* µg/L	150 (MCL[b])
	Trichloromethane	*0.03*–1.1 µg/L	100 (MCL[a])

Notes:
* Numbers in *italics* are estimates.
MCL[a] = Maximum Contaminant Level set by EPA (2005).
MCL[b] = Maximum Contaminant Level set by DWR.
µg/l = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
HAL = Health Advisory Level set by EPA (2005).
Source: Dawson 2001b, unless otherwise indicated.

Natural and agricultural processes affect groundwater quality in the North Yuba basin. Natural processes include those that influence the chemistry of the recharge water. The chemistry of the recharge water, surface geology, and soils influence the major ion chemistry and concentrations. The groundwater oxidation state also influences the form and presence of constituents. Much of the groundwater in the

North Yuba subbasin is chemically oxidizing. This results in lower concentrations of manganese and iron and the presence of nitrate and sulfate. Agricultural processes include use of fertilizers and pesticides and the evaporation of irrigation water. Groundwater from the North Yuba subbasin discharges to wells and streams. Specific processes affecting constituents of concern are discussed in some detail below.

Nutrients

Dawson (2001a) presented evidence for movement of nitrate to shallow groundwater in rice growing areas that included the North Yuba Subbasin. Specifically, she demonstrated a significant correlation of nitrate concentrations with well depth—higher nitrate concentrations were associated with shallower well depths indicating movement of nitrate from land surface associated with agricultural activities. Dawson (2001b) also presented evidence suggesting that nitrate concentrations are being lowered by chemical reactions in the groundwater that reduce nitrate to nitrogen gas. At this time, the data available for the Southeastern Sacramento Valley, an area that includes the North Yuba subbasin, show that shallow wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The eastern alluvial plains, in which North Yuba subbasin is located, contain magnesium-calcium-carbonate groundwater. Two processes appear to primarily affect groundwater salinity in the North Yuba subbasin: evaporation of irrigation water and shallow groundwater and mixing of naturally occurring groundwater (Hull 1984; Olmsted and Davis 1961; Dawson 2001a).

Pesticides

Rice pesticides Molinate, Thiobencarb, and Carbofuran were detected in wells sampled during the 1997 study by the USGS (Dawson 2001a) that included the North Yuba subbasin. The most prevalent pesticide detected in groundwater was bentazon. This chemical was used in rice fields until it was suspended in 1989 and officially banned in 1992. Its presence in groundwater in studies completed in 1997 (Domagalski et al. 2000) suggests it is readily transported in groundwater and does not degrade quickly. Although present in most wells in the rice growing areas of the Sacramento Valley in the 1997 study (Dawson 2001a), pesticides were only detected in one well in the North Yuba subbasin in the 1996 study (Dawson 2001b). This well was located just east of the Feather River near its confluence with the Yuba River. One pesticide was present in this domestic well at concentrations below the drinking water limits.

Other pesticides shown Table 4-19 include atrazine, bromacil, simizine, and tebuthiuron, which are used for weed control in right-of-way areas and for landscape maintenance. Simazine is used for weed control in right-of-way areas and for landscape maintenance, and on many crops grown in the study area, including nut and fruit orchards.

Dawson (2001a) investigated the relationship between groundwater quality and rice cultivation land use practices in data collected during 1997. She found that shallower groundwater had more occurrences of pesticide contamination than deeper groundwater, indicating the movement of pesticides from the ground surface downward.

Trace Elements

The chemistry of geology formations in the North Yuba subbasin influences the concentrations of trace elements. Dawson (2001a) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and zinc. Concentrations of silica were significantly higher in the eastern alluvial plain, which contains the North Yuba subbasin. Elevated concentrations of potassium were also present. The eastern alluvial plains showed higher concentration of arsenic than in the western alluvial plain. Dawson (2001b) presented evidence that the presence and concentration of arsenic is related to the dissolved oxygen concentration (or redox condition) of the groundwater. As the concentration of dissolved oxygen increases, the arsenic concentrations decrease. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Organic Carbon and DPBs

Since 1983 rice farmers have been required to hold or recirculate irrigation water for up to 30 days after pesticide application to allow for the pesticides to degrade or volatilize out of the water (Dawson 2001a). In addition, some rice fields are flooded during the winter months to aid in rice straw decomposition and provide winter habitat for migrating birds (Dawson 2001a).There is some evidence that these changes in management practices in rice may result in higher dissolved organic carbon concentrations in deep percolation water (Dawson 2001a). Dawson (2001a) did a study of groundwater quality in rice-growing areas of the western Sacramento Valley. Findings showed high dissolved organic carbon content in 43% of the wells in that study area. The median concentration was 2.7 mg/L, which is much higher than the national median of 0.7 mg/L (Leenheer et al. 1974).

Volatile Organic Compounds

VOCs have many different uses including pesticides gasoline, degreasers, solvents, and refrigerants. Some VOCs are byproducts of the chlorination of drinking water. VOCs were detected in three of the four wells in or on the border of the North Yuba subbasin in the 1996 study by Dawson (2001b). The VOCs found in the wells are consistent with the agricultural land uses in the subbasin, in that they were VOCs found in pesticides or gasoline.

Red Bluff Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Red Bluff subbasin is bounded on the west by the Coast Ranges, on the north by the Red Bluff Arch, on the south by Thomes Creek and on the east by the Sacramento River. The Red Bluff Arch is a hydrologic divide between the Redding Basin to the north and the Sacramento Valley. The Red Bluff subbasin is likely contiguous with the Corning subbasin at depth. The subbasin is about 274,700 acres (429 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Red Bluff subbasin is taken from DWR Bulletin 118 (DWR 2004).

The subbasin aquifer system is composed of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene stream channel deposits and Pleistocene Modesto and Riverbank formations. The Tertiary deposits consist of Pliocene Tehama and Tuscan formations.

Holocene stream channel deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Tehama Formation and Quaternary stream terrace deposits found at or near the surface along stream and river channels. The thickness varies from 1 to 80 feet. This unit represents the upper part of the unconfined zone of the aquifer. Although it is moderately to highly permeable it is not a significant contributor to groundwater because of its limited areal extent.

The Pleistocene Modesto Formation consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tehama and Riverbank Formations. The deposit ranges from less than 10 feet to nearly 200 feet across the valley floor. The terrace deposits are observed along Thomes, Elder, and Red Bank Creeks.

The Pleistocene Riverbank Formation consists of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. The formation ranges from less than one foot to over 200 feet thick depending on location. Riverbank terrace deposits are observed along Thomes, Pine, Dibble, Reeds, Red Bank, Oat, and Elder Creeks.

The Pliocene Tehama Formation consists of sediments originating from the Coast Range and Klamath Mountains, and is the primary source of groundwater for the subbasin. The majority of the Tehama Formation consists of fine-grained sediments indicative of deposition under floodplain conditions. The thickness of coarse-grained beds of sand and gravel, as indicated by drill log data, are typically no more than 5 to 10 feet. The majority of both coarse and fine-grained sediments appear unconsolidated or moderately consolidated. The thickness of the formation is estimated to be up to 1,200 feet north of the City of Corning.

The Pliocene Tuscan Formation consists of volcanic gravel and tuff-breccia, fine- to coarse-grained volcanic sandstone, conglomerate and tuff, and tuffaceous silt and clay; derived predominantly from andesitic and basaltic sources of the Cascade Range. In the subsurface the Tuscan Formation is found juxtaposed with the Tehama Formation in the axis of the valley near the Sacramento River. Permeability is moderate to high with yields ranging from 100 to 1,000 gpm, excluding areas where beds of the impermeable tuff-breccia exist.

Long-term groundwater level data indicate a decline of 3–7 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Generally, groundwater level data show a seasonal fluctuation ranging from 5 to 10 feet for unconfined, semiconfined, and composite wells. Wells constructed in confined aquifers can fluctuate up to 50 feet. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels.

Groundwater storage capacity was estimated to be about 4,209,000 acre-feet. This estimate was based on an average specific yield of 7.9% and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (19–27 inches/year), irrigation infiltration, and stream infiltration.

Estimate of groundwater extraction for agricultural use is estimated to be 81,000 acre-feet. Municipal and industrial use is approximately 8,900 acre-feet. Deep percolation of applied water is estimated to be 20,000 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 12% of the subbasin, urban land use accounts for about 5% of the subbasin, and native land accounts for about 83% of the subbasin. Table 4-20 provides details of the land uses within the subbasin.

Table 4-20. Land Use in the Red Bluff Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	620	0.20
Deciduous Fruits and Nuts	11,000	4.00
Field Crops	1,700	0.60
Grain and Hay	4,540	1.70
Pasture	8,870	3.20
Rice	1,530	0.60
Truck, Nursery, and Berry Crops	70	0.03
Idle	3,750	1.40
Semiagricultural and Incidental	860	0.30
Subtotal	32,910	12.00
Urban		
Urban—unclassified	310	0.10
Urban Landscape	340	0.10
Urban Residential	9,970	3.60
Commercial	680	0.20
Industrial	1,010	0.40
Vacant	2,240	0.80
Subtotal	14,550	5.30
Native		
Native Vegetation	219,000	79.70
Barren and Wasteland	2,300	0.80
Riparian	2,890	1.10
Water	3,030	1.10
Subtotal	227,220	82.70
Total	**274,380**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Red Bluff groundwater subbasin is within the Shasta-Tehama Watershed.

The public agencies within the subbasin are: Tehama County Flood Control and Water Conservation District. El Camino ID, Elder Creek WD, Gerber-Los Flores Community Service District, Gerber Water Works Inc., Tehama Ranch M.W.C., Proberta WD, Rawson WD, Thomes Creek WD, City of Red Bluff.

Tehama County adopted a groundwater ordinance in 1994 and a countywide AB 3030 groundwater management plan in 1996.

The city of Red Bluff is located within the subbasin.

Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance are off-parcel groundwater use, and influence of well pumping restrictions.

This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. TDS ranges from 120 to 500 mg/L and average 207 mg/L (DWR unpublished data). Impairments include high magnesium, TDS, calcium, ASAR, and phosphorus.

Solano Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Solano subbasin lies within the southwestern portion of the Sacramento Basin and the northern portion of the Sacramento-San Joaquin Delta. It is bounded by Putah Creek on the north, the Sacramento River on the east (from Sacramento to Walnut Grove), the North Mokelumne River on the southeast (from Walnut Grove to the San Joaquin River), the San Joaquin River on the south (from the North Mokelumne River to the Sacramento River) and a hydrologic divide between the San Francisco Bay and the Sacramento-San Joaquin River Delta on the west. The aquifer system is 664 square miles in size and lies in Solano, Sacramento, and Yolo Counties.

The following description of the hydrogeology in the Solano subbasin is taken from DWR Bulletin 118 (2004). The primary water-bearing formations comprising the Solano subbasin are sedimentary continental deposits of Late Tertiary to Quaternary age. Fresh water-bearing units include younger alluvium, older alluvium, and the Tehama Formation. The thickness of the units is nearly 3,000 feet near the eastern margin of the basin, thinning westward until they pinch out near the Coast Range. The Tehama Formation is underlain by saline water bearing sedimentary units that are generally considered the saline water boundary.

Flood basin deposits occur along the eastern margin of the subbasin and in the delta. Eastern flood basin deposits consist primarily of silts and clays, and may be locally interbedded with Sacramento River stream channel deposits. The flood basin deposits in the delta contain a significant percentage of organic material (peat). Thickness of the unit ranges from 0 to 150 feet. These deposits have low permeability and generally yield low quantities of water to wells.

Recent stream channel deposits occur along the Sacramento, Mokelumne and San Joaquin Rivers, and the upper reaches of Putah Creek, and consist of unconsolidated silt, fine- to medium-grained sand, and gravel with intermittent cobbles. The younger alluvium ranges in thickness from 0 to 40 feet but, with the exception of the Delta, generally lie above the saturated zone. The older alluvium ranges in thickness from 60 to 130 feet and has highly variable permeability. Deposits consist of loose to moderately compacted silt, silty clay, sand, and gravel from alluvial fan deposits. The coarser material usually occurs as lenses within the finer material. Well production within the unit can range from 50 to 4,000 gpm.

The Tehama Formation is the predominant water-bearing unit within the Solano subbasin, with thickness ranging from 1,500 to 2,500 feet. The formation consists of moderately compacted silt, clay, and fine silty sand enclosing lenses of sand and gravel; silt and gravel; and cemented conglomerate. Because of its large extent, wells completed in the Tehama Formation can yield up to several thousand gallons per minute, although its permeability is generally less than the overlying younger units.

Brackish to saline water-bearing sedimentary units of volcanic and marine origin underlie the Tehama Formation at depths ranging from a few hundred feet on the west to nearly 3,000 feet on the east of the subbasin. The contact between the Tehama Formation and these units is generally considered to coincide with the boundary between fresh and saline water.

According to DWR Bulletin 118 (2004), agricultural and urban development has resulted in significant decreases in groundwater elevations from historical levels. A large pumping depression has formed just north of the Delta. (DWR 1978.) Subsequent to the onset of surface water deliveries in 1959, however, water levels have recovered slightly or slowed their decline. Periods of drought in the 1970s and 1980s have significantly affected groundwater level trends, but these impacts have been offset by subsequent wet years. Average specific yield is estimated to be 0.07 for the Sacramento Valley and 0.08 for the Delta.

Major Sources of Recharge

The principal sources of stream recharge for the Solano subbasin are Putah Creek and the Sacramento River. Hydrochemical facies analysis indicates that the surface water from Putah Creek contributes to groundwater both near the creek and south into the center of Solano County (Evenson 1984). Deep percolation of water applied as crop irrigation is another source of recharge, but is secondary to the combination of streamflow and precipitation, as soils containing hardpan and clay in areas other than along streams impede vertical percolation in the Solano subbasin (DWR 1978).

Annual precipitation for the subbasin ranges from approximately 16 to 23 inches, with higher precipitation occurring to the west.

Land Use

Land use surveys were conducted within the subbasin by DWR. Agricultural land use accounts for about 67% of the subbasin, urban land use accounts for about 4% of the subbasin, and native land accounts for about 28% of the subbasin. Table 4-21 provides details of the land uses within the Solano Subbasin.

Table 4-21. Land Use in the Solano Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	48	0.01
Deciduous Fruits and Nuts	10,738	2.52
Field Crops	98,892	23.23
Grain and Hay	73,196	17.19
Idle	5,739	1.35
Pasture	56,667	13.31
Semiagricultural and Incidental	3,154	0.74
Truck, Nursery, and Berry Crops	30,788	7.23
Vineyards	7,145	1.68
Subtotal	286,367	67.26
Urban		
Urban—unclassified	8,606	2.02
Commercial	468	0.11
Industrial	1,621	0.38
Urban Landscape	450	0.11
Urban Residential	2,104	0.49
Vacant	2,455	0.58
Subtotal	15,704	3.69
Native		
Native—unclassified	578	0.14
Native Vegetation	87,444	20.54
Barren and Wasteland	6	0.00
Riparian	7,983	1.87
Water	24,993	5.87
Subtotal	121,004	28.42
Unknown	**2,697**	**0.63**
Total	**425,772**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Public water agencies included in the Solano Subbasin include City of Dixon, City of Rio Vista, California Water Service, City of Vacaville, and University of California, Davis. Private water agencies include Maine Prairie Water District, Solano Irrigation District, Solano County Water Agency, North

Delta Water Agency, and RDs 501, 536, 1607, 1667, 2060, 2068, 2084, 2093, 2098, 2104, and 2112 (DWR 2004).

AB 3030, a 1992 amendment to the Water Code, provides a systematic procedure for local agencies to develop a groundwater management plan for underlying groundwater basins as defined in DWR Bulletin 118-75 and updates. Agencies adopting a plan have authority, contingent on receiving a majority of votes in a local election, to collect revenues for implementation of groundwater management measures. An AB 3030 management plan for the Solano subbasin was adopted by the City of Vacaville and the Solano Irrigation District in February of 1995, and by the Maine Prairie Water District and RD 2068 in January of 1997 (DWR 2004).

This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater within the Solano Subbasin is considered to be of generally good quality, and useable for both domestic and agricultural purposes. However, groundwater in some of the southwestern portion of the Sacramento Valley, which includes the Solano Subbasin, is not entirely suitable for human or agricultural use because of the presence of elevated levels of boron, fluoride, chloride, nitrate, and sulfate.

Chemical water types within the basin are variable and classified generally as magnesium bicarbonate in the central and northern areas, sodium bicarbonate in the southern and eastern areas, and calcium magnesium or magnesium calcium bicarbonate around and west of Dixon.

A USGS study (Evenson 1984) analyzed water quality in the Solano and Yolo Counties. Constituents that were measured include: dissolved solids, hardess, chloride, fluoride, sulfate, nitrogen, arsenic, boron, iron, and manganese. Unless otherwise noted, the following is a summary of the findings from that report, as they pertain to the Solano Subbasin.

Dissolved Solids

TDS ranges from 250 to 500 mg/L in the northwest and eastern portion of the basin and are found at levels higher than 500 mg/L in the central and southern areas. Data from the CDPH in 2000 (DWR 2004) shows the TDS minimum = 150 mg/L, maximum = 880 mg/L, average = 427 mg/L. Hardness, which is mainly a reflection of the amount of calcium and magnesium in water, is considered very high, with values generally greater than 180 mg/L. According to CDPH data (DWR 2004), about one half of drinking water well samples taken between 1970 and 2000 analyzed for overall hardness measured above 200 mg/L, but rarely over 400 mg/L. High concentrations of bicarbonate, which causes precipitation of Ca and Mg carbonates, is found in the southern portion of the basin (Hull 1984).

Boron

Boron concentrations are less than 0.75 ppm except in the southern and southeastern basin where concentrations average between 0.75 and 2.0 ppm (more than 1.0 ppm will affect sensitive tree crops). Concentrations are high along the Sacramento River and seem to increase in a southwesterly direction.

Iron

Iron concentrations are generally low with respect to federal standards (MCL = 0.3 ppm) in the Solano subbasin. Iron concentrations increase toward the eastern side of the subbasin, from less than 0.02 ppm to greater than 0.05 ppm along the Sacramento River.

Manganese

Manganese concentrations increase from west to east with concentrations from 0.01 ppm to over 0.1 ppm found north of Rio Vista and east of the Solano-Yolo County line. Manganese is found at concentrations above the MCL of 0.05 ppm (as a secondary constituent) along the Sacramento River along the eastern portion of the subbasin (DWR 2004).

Arsenic

Arsenic concentrations are typically between 0.02 and 0.05 ppm, with the highest concentrations found along the southeastern margin of the basin. Although this is currently not considered problematic, there could be impacts if the MCL is lowered. The current MCL (as set by the EPA [2005]) for arsenic is 0.05 ppm (DWR 2004).

Chloride

Chloride concentrations are highest in the southwestern part of the subbasin, with values greater than 100 mg/L. The lowest levels exist in the eastern central and northwestern sections, with values generally below 25 mg/L. The MCL for chloride is 600 ppm. The EPA secondary standard for chloride is 250 mg/L. According to a study in Sacramento County (DWR 1974), the average chloride ion concentration in the Delta region was measured at 132 mg/L, with a range of 6 mg/L to 904 mg/L.

Fluoride

Fluoride concentrations are generally greater than 0.5 mg/L in the southwestern portion of the basin and less than 0.5 mg/L in the east and north. EPA optimum fluoride concentration for this area is 0.8 mg/L.

Sulfate

Sulfate concentrations are low over the study area with respect to the recommended limits. The highest concentrations are in the southern areas, with values greater than 50 ppm. The MCL for sulfate is 600 ppm.

Nitrogen

There were several domestic wells with nitrogen as nitrate concentrations above the EPAMCL of 10 mg/L, ranging from 11 mg/L to 45 mg/L.

Pesticides

According to DPR (2004), there were 2 detections of DBCP (soil fumigant) and 1 detection of diquat dibromide (herbicide) in Sacramento County. For the period of 1985 to 2003 (DPR 2003), atrazine and bentazon were detected in Sacramento County, ACET, atrazine, DACT, DEA, diuron, norflurazon, prometon, and simazine were detected in Solano County, and atrazine, bentazon, and simazine were detected in Yolo County. The sampling locations and concentrations were not specified.

Summary of Significant Detections

Of the 71 public supply wells sampled by DWR, CDPH and their cooperators (DWR 2004), 1 well had primary inorganics concentrations above the MCL, 8 wells of 96 sampled had nitrate concentrations above the MCL, 3 wells out of 56 sampled had pesticide concentrations above the MCL, 1 well of 57 sampled had VOC/SVOC concentrations above the MCL, and 17 wells of 71 sampled had secondary inorganics concentrations above the MCL.

Discharge Pathways and Sources of Contaminants

Discharge occurs as flow to the Sacramento River and other streams and from evapotranspiration from vegetation. Irrigated agriculture appears to be a source of pesticide contamination.

South American Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The South American groundwater subbasin is bound by the Sierra Nevada foothills on the east, the Sacramento River on the west, the American River on the north, and the Cosumnes and Mokelumne Rivers on the south. The subbasin is 388 square miles in size and is located entirely within Sacramento County.

The following description of the hydrogeology in the South American subbasin is taken from DWR Bulletin 118 (DWR 2004).

The South American subbasin aquifer system is comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include younger alluvium (consisting of flood basin deposits, dredge tailings and Holocene stream channel deposits), older alluvium, and Miocene/Pliocene volcanics. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 2,500 feet along the western margin of the subbasin. The maximum combined thickness of all the younger alluvial units is about 100 feet. Calculated specific yield values range from about 5.4% in the flood basin deposits to 10% in the stream channel deposits.

The flood basin deposits occur along the western margin of the subbasin adjacent to the Sacramento River. They consist primarily of silts and clays, but along the western margin of the subbasin may be locally interbedded with stream channel deposits of the Sacramento River. The flood basin deposits are generally fine-grained, have low permeability, and generally yield low quantities of water to wells.

Dredge tailings are exposed primarily along the American River in the northeastern corner of the subbasin. They consist of windows of gravel, cobbles, boulders, sand, and silt resulting from the activities of gold dredging operations. The tailings are highly permeable, but well construction is complicated by the presence of cobbles and boulders.

The stream channel deposits include sediments deposited in the channels of active streams as well as overbank deposits of those streams, terraces, and local dredger tailings. They occur along the Sacramento, American, and Cosumnes Rivers and their major tributaries and consist primarily of unconsolidated silt, fine- to medium-grained sand, and gravel. Sand and gravel zones in the younger alluvium are highly permeable and yield significant quantities of water to wells.

The older alluvium deposits consist of loosely to moderately compacted sand, silt, and gravel deposited in alluvial fans during the Pliocene and Pleistocene. A number of formational names have been assigned to the older alluvium, including the Modesto Formation, Riverbank Formation, Victor Formation, Laguna Formation, Arroyo Seco Gravels, South Fork Gravels, and Fair Oaks Formation. The older alluvial units are widely exposed between the Sierra Nevada foothills and overlying younger alluvial units near the axis of the Sacramento Valley. Thickness of the older alluvium is about 100–650 feet. It is moderately permeable. The calculated specific yield of these deposits is about 7%.

The Miocene/Pliocene volcanics consist of the Mehrten Formation, a sequence of fragmental volcanic rocks, which crops out in a discontinuous band along the eastern margin of the basin. It is composed of intervals of “black sands,” stream gravels, silt, and clay interbedded with intervals of dense tuff breccia. The sand and gravel intervals are highly permeable and wells completed in them can have high yields. The tuff breccia intervals act as confining layers. Thickness of the unit is between 200 and 1,200 feet.

Groundwater levels declined approximately 20 feet from the mid-1960s to about 1980. From 1980 through 1983 water levels recovered by about 10 feet and remained stable until the beginning of the 1987 through 1992 drought. From 1987 until 1995, water levels declined by about 15 feet. From 1995 to 2000 most water levels recovered by up to 20 feet leaving them generally higher than levels prior to the 1987 through 1992 drought. DWR (2004) estimated the specific yield to be 6.8% and the storage capacity (to a depth of 310 feet) to be 4.8 maf. The bounding rivers form groundwater flow divides in the shallow zone, but there is lateral groundwater flow between adjacent subbasins in the deeper zones.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (14-20 inches/year), irrigation infiltration, and stream infiltration. Average annual recharge for the period 1975-90 was estimated using a groundwater-flow model. The model estimated the recharge to be 357,000 acre-feet, subsurface outflow was 29,700 acre-feet, pumpage for irrigation was 163,000 acre-feet, and pumpage for public supply was 68,000 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 2000. Agricultural land use accounts for about 26% of the subbasin, urban land use accounts for about 37% of the subbasin, and native land accounts for about 37% of the subbasin. Table 4-22 provides details of the land uses within the subbasin.

Table 4-22. Land Use in the South American Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	60	0.02
Deciduous Fruits and Nuts	2,990	1.20
Field Crops	16,300	6.70
Grain and Hay	6,170	2.50
Pasture	17,500	7.20
Rice	250	0.10
Truck, Nursery, and Berry Crops	4,430	1.60
Vineyards	12,100	5.00
Idle	1,430	0.60
Semiagricultural and Incidental	1,500	0.60
Subtotal	62,730	25.70
Urban		
Urban—unclassified	62,200	25.40
Urban Landscape	3,210	1.30
Urban Residential	7,160	2.90
Industrial	6,790	2.80
Commercial	730	0.30
Vacant	10,500	2.90
Subtotal	90,590	37.10
Native		
Native Vegetation	73,700	30.20
Barren and Wasteland	8,180	3.30
Riparian	5,180	2.10
Water	4,030	1.60
Subtotal	91,090	37.30
Total	244,410	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The North American groundwater subbasin is within the Placer North Sacramento Watershed.

The public agencies within the South American subbasin are: Arden Cordova Water Service, City of Folsom, City of Sacramento, County of Sacramento, Elk Grove Water Works, Florin County WD, Fruitridge Vista, Mather Air Force Base, North Delta Water Agency, Omochumne-Hartnell WD, Rancho Murieta CSD, Tokay Park, Sacramento County WMD, and Sacramento County WMD- Zone 40 (DWR 2004).

The SGA is a joint powers authority formed to manage the North Area Groundwater Basin, which is north of the South American subbasin. The Regional Water Authority (RWA) is a joint powers authority that serves and represents the interests of 21 water providers in the greater Sacramento, Placer, and El Dorado County region.

The Sacramento Metropolitan urban is partly located within the subbasin including the cities of Sacramento, Rancho Cordova, Folsom, and Elk Grove.

This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater is typically a calcium magnesium bicarbonate or magnesium calcium bicarbonate. Other minor groundwater types include a sodium calcium bicarbonate or calcium sodium bicarbonate in the vicinity of Elk Grove and a magnesium sodium bicarbonate or sodium magnesium bicarbonate near the confluence of the Sacramento and American rivers (Bertoldi et al. 1991). TDS ranges from 24 to 581 mg/L and averages 221 mg/L based on 462 records (Montgomery Watson 1993).

Sites with significant groundwater contamination exist within the subbasin. These sites include Aerojet, Mather Field, and the Sacramento Army Depot, the Kiefer Boulevard Landfill, an abandoned Pacific Gas and Electric Company (PG&E) site near Old Sacramento, and the Southern Pacific and Union Pacific Rail Yards in downtown Sacramento.

Discharge Pathways and Sources of Contaminants

Natural, agricultural, and urban land use practices affect groundwater quality in the South American basin. Natural processes include those that influence the chemistry of the recharge water. The chemistry of the recharge water, surface geology, and soils influence the major ion chemistry and concentrations. The groundwater oxidation state also influences the form and presence of constituents. Much of the groundwater in the South American subbasin is chemically oxidizing. This results in lower concentrations of manganese and iron and the presence of nitrate and sulfate. Agricultural processes include use of fertilizers and pesticides and the evaporation of irrigation water. Specific processes affecting constituents of concern are discussed in some detail below.

Nutrients

The available data for the Southeastern Sacramento Valley, an area that includes the South American subbasin, show that 8 of the 31 wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The groundwater in the South American subbasin is mostly calcium magnesium bicarbonate or magnesium calcium bicarbonate. Although some localized areas of sodium calcium bicarbonate or calcium sodium bicarbonate and magnesium sodium bicarbonate or sodium magnesium bicarbonate exist. The high amount of sodium and chloride in some wells may be due to natural or anthropogenic causes.

Two processes appear to primarily affect groundwater salinity in the North American subbasin. The first is evaporation of irrigation water and shallow groundwater. The second is mixing of naturally occurring groundwater with naturally occurring groundwater of a higher salinity. (Hull 1984; Olmsted and Davis 1961; Dawson 2001a.)

Pesticides

Pesticides were detected in three of the five wells in a study of the Southeast Sacramento Valley (Dawson 2001b). All concentrations were below the drinking water limits.

The most common pesticides detected in Dawson's (2001b) 1996 study of the Southeastern Sacramento Valley were bentazon, simazine, atrazine, bromacil, and tebuthiuron. The major uses for atrazine, bromacil, and tebuthiuron are for weed control in right-of-way areas and for landscape maintenance. Simazine is used for weed control in right-of-way areas and for landscape maintenance, and on many crops grown in the study area, including nut and fruit orchards.

Trace Elements

The chemistry of geology formations in the South American subbasin influences the concentrations of trace elements. In a study of the Southeastern Sacramento Valley (Dawson 2001b), which includes part of the South American subbasin, drinking water standards were exceeded for five inorganic constituents: chloride, boron, iron, manganese, and arsenic.

Dawson (2001b) presented evidence that, within the Southeastern Sacramento Valley, the concentration of arsenic is related to the dissolved oxygen concentration (or redox condition) of the groundwater. She found that as the concentration of dissolved oxygen increases, the arsenic concentrations decrease. The presence of trace constituents in groundwater in the South American Subbasin do not appear to be related to irrigated agriculture.

Volatile Organic Compounds

VOCs have many different uses including pesticides gasoline, degreasers, solvents, and refrigerants. Some VOCs are byproducts of the chlorination of drinking water. VOCs were detected in two of the five wells in the South American (Dawson 2001b). The VOCs found in the wells are consistent with the land use surrounding each well. Those detected in agricultural areas were VOCs found in pesticides or gasoline while those detected in urban areas were VOCs associated with landscape maintenance, pest control, right-of-way weed control, gasoline, industrial chemicals and chlorinated drinking water. Aerojet Superfund site is located in the South American basin and 8 VOCs were detected in the well on that particular site. The site is currently undergoing remediation.

South Yuba Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The South Yuba subbasin is bounded on the north by the Yuba River, on the west by the Feather River, on the south by the Bear River, and on the east by the Sierra Nevada foothills. The subbasin is 104,400 acres (163 square miles) in size and is located entirely within Yuba County.

The following description of the hydrogeology in the South Yuba subbasin is taken from DWR Bulletin 118 (DWR 2004).

The South Yuba Subbasin aquifer system is comprised of continental deposits of Quaternary (Recent) to Late Tertiary (Miocene) age. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 1,400 feet along the western margin of the basin. The base of the aquifer system overlies the Pre-Tertiary metamorphosed igneous and sedimentary rocks of the Sierra Nevada block.

Holocene Dredge deposits occur along the Yuba and Bear Rivers within the eastern region of the South Yuba Groundwater subbasin. The coarse gravels and cobbles can be up to 125 feet thick and are highly permeable.

Holocene Stream Channel and Floodplain deposits occur as coarse sand and gravels along present stream channels of the Yuba, Feather, and Bear Rivers. Coarser grained materials occur near streams with thicknesses up to 110 feet. Both grain size and thickness decrease with increased distance from streams. These deposits are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Well yields are reported in the range of 2,000 to 4,000 gpm.

The Pleistocene Victor Formation lies unconformably above the Laguna Formation. The majority of the formation occurs as alluvium throughout the North Yuba Groundwater subbasin, but floodplain deposits are present along stream channels above the alluvium.

Pleistocene Floodplain deposits occur as gravelly sand, silt, and clay from flood events along the Feather River and its tributaries. This unit overlies the Older Alluvium, underlies Quaternary Deposits, and ranges in thickness from 5 to 15 feet. These deposits provide a good medium for groundwater recharge, provided the groundwater can pass the lower contact with the Older Alluvium.

Pleistocene Alluvium occurs at over 50% of the basin surface and at least 60% of its irrigated agricultural lands. Its thickness is highly variable due to its lower contact with the Laguna Formation. The Older Alluvium is comprised of Sierran alluvial fan deposits of loosely compacted silt, sand, and gravel with lesser amounts of clay deposits. The deposits occur as lenticular beds with decreasing thickness and grain size with increasing distance from the Yuba River and the foothills. Hardpan and claypan soils have developed to form an impermeable surface, but below this the Older Alluvium is moderately permeable and provides for most of the groundwater from domestic and shallow irrigation wells. Wells in the older alluvium have yields up to 1,000 gpm.

The Pliocene Laguna Formation is the most extensive water-bearing unit within the South Yuba Groundwater subbasin. The formation is comprised of reddish to yellowish or brown silt to sandy silt with abundant clay and minor lenticular gravel beds. It overlies the Mehrten Formation and occurs at the surface intermittently at the east end of the basin. The continental deposits of the Laguna dip to the west beneath the Victor Formation and range in thickness from 400 feet near the Yuba River up to 1,000 feet in the southwest portion of the county. Although the occurrence of thin sand and gravel zones is common, many of them have reduced permeability due to cementation. This coupled with its fine-grained character, leads to an overall low permeability for the Laguna Formation. Most of the groundwater produced from wells in the Laguna comes from overlying units.

The Miocene-Pliocene Mehrten Formation is a sequence of volcanic rocks of late Miocene through middle Pliocene age. Surficial exposures are limited to a few square miles in the northeast corner of the basin and thickness varies from 200 feet near the eastern margin of the basin to 500 feet near the Feather River. The Mehrten Formation is composed of two distinct units. One unit occurs as intervals of gray to black, well-sorted fluvial andesitic sand (up to 20 feet thick), with andesitic stream gravel lenses and brown to blue clay and silt beds. These sand intervals are highly permeable and wells completed in them can produce high yields. The second unit is an andesitic tuff-breccia that acts as a confining layer between sand intervals.

As early as 1960 groundwater levels showed a well-developed cone of depression beneath the South Yuba basin. Water levels in the center of the cone of depression were just below sea level. Nearly all water levels were well below adjacent river levels on the Bear, Feather, and Yuba Rivers. Groundwater conditions in 1984 reflect a continued reliance on groundwater pumping in the South Yuba Basin. Water levels in the center of the South Yuba cone of depression had fallen to 30 feet below sea level. The water level contours adjacent to the Bear and Yuba Rivers indicated a large gradient and seepage from the rivers. By 1990, water levels in the South Yuba Basin cone of depression rose to 10 feet above sea level. The rise in water levels was due to increasing surface water irrigation supplies and reduced groundwater pumping. Current DWR records indicate groundwater levels continue to increase.

Groundwater storage capacity was estimated to be 1,090,000 acre-feet. This estimate was based on an area of 88,700 acres, an average specific yield of 6.9%, and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (20–24 inches/year), irrigation infiltration, and stream infiltration. Stream channel and floodplain deposits present along the Yuba River, Feather River, and Honcut Creek are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Previous DWR unpublished studies have estimated natural and applied recharge. DWR has also estimated urban and agriculture extractions and subsurface outflow. Basin inflows include natural recharge of 53,700 acre-feet, and applied water recharge of 26,000 acre-feet. Outflows include urban extraction of 6,000 acre-feet, agricultural extraction of 93,400 acre-feet, and subsurface outflow of 4,900 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 50% of the subbasin, urban land use accounts for about 9% of the subbasin, and native land accounts for about 41% of the subbasin. Table 4-23 provides details of the land uses within the subbasin.

Table 4-23. Land Use in the South Yuba Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	140	0.10
Deciduous Fruits and Nuts	20,600	19.70
Field Crops	1,410	1.30
Grain and Hay	1,100	1.10
Pasture	9,140	8.70
Rice	16,900	16.20
Truck, Nursery, and Berry Crops	430	0.40
Idle	2,300	2.20
Semiagricultural and Incidental	720	0.70
Subtotal	52,740	50.40
Urban		
Urban—unclassified	4,100	25.40
Urban Landscape	420	1.30
Urban Residential	600	2.90
Industrial	1,230	2.80
Commercial	100	0.30
Vacant	2,540	2.90
Subtotal	8,990	8.60
Native		
Native Vegetation	35,400	30.20
Barren and Wasteland	3,900	3.30
Riparian	2,140	2.10
Water	1,140	1.60
Subtotal	42,580	41.00
Total	**104,310**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The South Yuba groundwater subbasin is within the Butte Sutter Yuba Watershed. The public agencies within the South Yuba subbasin are: Yuba County Water Agency, Brophy Water District, Linda County Water District, Wheatland Water District, South Yuba Water District, Plumas Water District, RD 794 (DWR 2004).

The South Yuba Water District completed an AB 3030 plan in 1998. No major urban areas exist within the subbasin. The cities of Marysville and Yuba City are located at the northwestern boundary of the subbasin. This subbasin falls within the area included in the Sacramento Valley and Rice Water Quality Coalitions.

Water Quality

. In general, TDS concentrations are below 500 mg/L throughout the entire subbasin. DWR maintains data for 27 water quality wells in the South Yuba Subbasin. Data collected from these wells indicate a TDS range of 141 to 686 mg/L and a median of 224mg/L. The primary water chemistry in the area indicates calcium magnesium bicarbonate or magnesium calcium bicarbonate groundwater. Some magnesium bicarbonate can be found in the northwest portion of the basin.

Groundwater quality issues in the South Yuba subbasin include excess nutrients, trace elements, salinity, and pesticides. Pesticides occur in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring but some are found at levels above the MCL. Elevated nitrates are possibly due to on-site sewage systems (PMC 1996). However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the South Yuba subbasin (Dawson 2001b). Tables 4-24 and 4-25 summarize the available data.

Table 4-24. Water Quality in the South Yuba Subbasin

Constituent of Concern	Available Information about Groundwater Concentrations for South Yuba Subbasin
Nutrients	Median nitrate concentrations for the southeastern Sacramento Valley, including South Yuba subbasin was 1.4 mg/L. Only one well in the study area exceeded drinking water standards.
Pesticides (insecticides and herbicides) and degradation products	DPR verified bentazon detection in 10 wells with in Yuba County from 1996 to 2003. Pesticides detected in one domestic well in 1996 study, but concentrations werebelow drinking water standards.
Salt—primarily as electrical conductivity and total dissolved solids.	141 to 686 mg/L, median is 224mg/L.
Trace elements	High concentration of arsenic (naturally occurring) in some areas.
Organic carbon and disinfection byproduct precursors	No available data.
Microorganisms	No available data.
Volatile organic compounds	VOCs were detected in 2 wells in the South Yuba subbasin. Concentrations below drinking water standards.

Notes:
mg/L = milligrams per liter.
Sources: Dawson 2001b; DPR 2004b.

Table 4-25. Concentrations of Constituents of Concern Detected in the Southeastern Sacramento Valley Aquifers, including the South Yuba Subbasin

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
Nutrients	Nitrate—Ammonia as N	0.02–0.11 mg/L	30 (HAL)
	Nitrate as N	0.06–12mg/L	10 (MCL[a])
	Nitrite as N	0.01–0.01 mg/L	1 (MCL[a])
	Orthophosphate, as P	0.03–0.4 mg/L	
	Phosphorus, as P	0.03–0.45 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	0.001–0.001 µg/L	3 (MCL[a])
	Bentazon	0.02–1.3 µg/L	18 (MCL[b])
	Bromacil	0.34 µg/L (one detection)	90 (HAL)
	Desethyl atrazine	0.004–0.044 µg/L	
	Simazine	0.006–0.077 µg/L	4 (MCL[a])
	Tebuthiuron	0.32 µg/L (one detection)	500 (HAL)
Salt—primarily as electrical conductivity and total dissolved solids.		141–686 mg/L, median is 224mg/L (DWR 2004) 134–1,750 mg/L, median is 258 mg/L	500 (SMCL)
Inorganic Constituents			
	Arsenic	1–46 µg/L	50 (MCL[a])
	Bicarbonate	67–413 mg/L	
	Boron	12–110 µg/L	600 (HAL)
	Bromide	0.02–12 mg/L	
	Calcium	10–210 mg/L	
	Chloride	2.0–620 mg/L	250 (SMCL)
	Fluoride	0.1–0.3 µg/L	4 (MCL[a])
	Iron Fe	3–1,600 µg/L	300 (SMCL)
	Magnesium	5.0–100 mg/L	
	Manganese	1–870 µg/L	50 (SMCL)
	Potassium	0.40–4.1 mg/L	
	Silica	24–86 mg/L	
	Sodium	5.7–120 mg/L	
	Sulfate	1.0–130 mg/L	250 (SMCL)
	Total Hardness as $CaCO_3$	48 (soft)–940 (very hard) mg/L, median is 135 mg/L	
Organic carbon and disinfection byproduct precursors	DOC	0.2–0.7 mg/L, median 0.3 mg/L	
Volatile organic compounds*	1,1-Dichloroethane	*0.02*–0.04 µg/L	
	1,2,4-Trimethylbenzene	*0.01*–0.02 µg/L	
	1,2-Dichloroethane	0.19 µg/L	0.5 (MCL[a])
	Bromodichloromethane	*0.03* µg/L	100 (MCL[a])
	cis-1,2-Dichloroethene	0.43 µg/L	6 (MCL[b])

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
	Dichlorodifluoromethane	*0.04*–0.29 µg/L	1000 (HAL)
	Methyl tert-butyl ether	*0.06* µg/L	20 (HAL)
	Styrene	0.06 µg/L	100 (MCL[a])
	Tetrachloroethene	0.58–0.97 µg/L	5 (MCL[a])
	Tetrachloromethane	1.2 µg/L	0.5 (MCL[b])
	Trichloroethene	*0.01*–5.5 µg/L	5 (MCL[a])
	Trichlorofluoromethane	*0.04* µg/L	150 (MCL[b])
	Trichloromethane	*0.03*–1.1 µg/L	100 (MCL[a])

Notes:
* Numbers in *italics* are estimates.
MCL[a] = Maximum Contaminant Level set by EPA (2005).
MCL[b] = Maximum Contaminant Level set by DWR.
µg/l = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
HAL = Health Advisory Level set by EPA (2005).
Source: Dawson 2001b, unless otherwise indicated.

Nutrients

Dawson (2001a) presented evidence for movement of nitrate to shallow groundwater in rice growing areas. Specifically, she demonstrated a significant correlation of nitrate concentrations with well depth—higher nitrate concentrations were associated with shallower well depths indicating movement of nitrate from land surface associated with agricultural activities. There are naturally occurring nitrates in some formations of the Sacramento Valley. However, most nitrogen species that occur above 3 mg/L signify contamination introduced into the groundwater via human activates such as agriculture and urbanized development. At this time, the data available for the Southeastern Sacramento Valley, an area that includes the South Yuba subbasin, show that 8 of the 31 wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The eastern alluvial plains, in which the South Yuba subbasin is located, contain magnesium-calcium-carbonate groundwater. Two processes appear to primarily affect groundwater salinity in the South Yuba subbasin: evaporation of irrigation water followed by its percolation and shallow groundwater mixing with naturally occurring groundwater (Hull 1984, Olmsted and Davis 1961, Dawson 2001a). Using isotope data, Dawson (2001a) presented evidence that partial evaporation as indicated by the isotope data accounted for some of the measured increase in salinity among shallow groundwater samples. The South Yuba subbasin does not appear to be adversely affected by saline groundwater, the median concentration of dissolved solids is 224 mg/L.

Trace Elements

Concentrations of silica were significantly higher in the eastern alluvial plain, which contains the South Yuba subbasin. Elevated concentrations of potassium were also present. The eastern alluvial plains showed higher concentration of arsenic than in the western alluvial plain.

Volatile Organic Compounds

VOCs have many different uses including pesticides gasoline, degreasers, solvents, and refrigerants. Some VOCs are byproducts of the chlorination of drinking water. VOCs were detected in two wells in the South Yuba subbasin in the 1996 study by Dawson (2001b). The VOCs found in the wells were consistent with the agricultural land uses in the subbasin in that they were VOCs found in pesticides or gasoline.

Sutter Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Hydrogeology

The Sutter subbasin aquifer boundaries are the confluence of Butte Creek and the Sacramento River and Sutter Buttes on the north, the confluence of the Sacramento River and the Sutter Bypass on the south, the Sacramento River on the west, and the Feather River on the east. The aquifer system is 366 square miles in size and is located in Sutter County.

The following description of the hydrogeology in the Sutter subbasin is taken from DWR Bulletin 118 (2004). The geologic formations of the Sutter Subbasin include pre-Cretaceous metamorphic and igneous rocks of the Sierra Nevada block, which extends beneath the valley fill overlain principally by Tertiary sedimentary formations derived from these and other rocks that are exposed in the Sierra Nevada to the east. The sedimentary rocks are of both marine and continental origin and are frequently interbedded with tuff-breccias. Volcanic rocks are also represented in the area in and around Sutter Buttes, which are erosional remnants of an extinct Pliocene volcano. Only the sedimentary rocks can be considered as being water bearing to any appreciable degree.

The Sutter Subbasin aquifer system is comprised of continental deposits of Quaternary (Recent) to Late Tertiary (Miocene) age. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 2,000 feet along the western margin of the basin (DWR 1978).

The Holocene stream channel and floodplain deposits occur as coarse sand and gravel along present stream channels of the Yuba, Feather, and Sacramento Rivers. Coarser grained materials occur near streams with thicknesses up to about 100 feet. Both grain size and thickness decrease with increased distance from streams. These deposits are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Well yields are reported in the range of 2,000 to 4,000 gpm.

The Pleistocene floodplain deposits occur as gravelly sand, silt, and clay from flood events along the Feather River and its tributaries. This unit overlies the Older Alluvium, underlies Quaternary Deposits, and ranges in thickness up to about 100 feet. These deposits provide a good medium for groundwater recharge, provided the groundwater can pass the lower contact with the Older Alluvium.

The Pleistocene Victor Formation (Old Alluvium) ranges in thickness up to about 100 feet. This formation is comprised of Sierran alluvial fan deposits of loosely compacted silt, sand, and gravel with lesser amounts of clay deposits. The deposits occur as lenticular beds with decreasing thickness and grain size with increasing distance from the Yuba River and the foothills. Hardpan and claypan soils have developed to form an impermeable surface, but below this the Older Alluvium is moderately permeable and provides for most of the groundwater from domestic and shallow irrigation wells. Wells in the older alluvium have yields up to 1,000 gpm.

The Pliocene Laguna Formation consists of compacted layers of sand, silt, and clay with hardpan in surface soils. In the subsurface, this formation has a thickness of about 300 feet but is estimated to be up to 1,000 feet along the valley axis. Although the occurrence of thin sand and gravel zones is common, many of them have reduced permeability due to cementation. This coupled with its fine-grained character, leads to an overall low permeability for the Laguna Formation. This formation is an important source of water for southeastern Sacramento Valley.

The Miocene - Pliocene Mehrten Formation is a sequence of volcanic and volcaniclastic rocks of late Miocene through middle Pliocene age. The formation ranges in thickness from about 200 feet to over 1,000 feet along the axis of the valley. The Mehrten Formation is composed of two distinct units: One unit occurs as intervals of gray to black, well-sorted fluvial andesitic sand (up to 20 feet thick), with andesitic stream gravel lenses and brown to blue clay and silt beds. These sand intervals are highly permeable and wells completed in them can produce high yields. The second unit is an andesitic tuff-breccia that acts as a confining layer between sand intervals. This formation is also an important source of water for southeastern Sacramento Valley.

The Oligocene - Miocene Valley Springs Formation consists of gravel, sand, silt, and clay, siltstone, and tuffaceous beds which all contain rhyolitic material. This unit is reported to have a maximum thickness of about 200 feet. The Valley Springs Formation deposits typically have low permeabilities and therefore, yield only small quantities of water to wells.

Groundwater levels in the Sutter subbasin tend to remain constant. In Bulletin 188-6 (DWR 1978), average annual groundwater recharge was documented to exceed average discharge in the Sutter subbasin. DWR (2004) estimated the storage capacity (200-foot depth) to be 5 maf. The depth to the aquifer in most locations is about 10 feet below ground surface.

Major Sources of Recharge

Stream infiltration, irrigation, and precipitation are the principal sources of recharge to the Sutter subbasin. The Sacramento and Feather Rivers provide recharge to the aquifer as well as irrigation from agricultural fields. Annual precipitation ranges from 17 to 21 inches with rainfall increasing across the valley from the southeast to the northwest (DWR 2004). Twenty-three percent of the Sutter subbasin is used for rice cultivation where the fields are typically flooded for 6 months each year. DWR (2004) estimated inflows to the subbasin from natural recharge to be 40,000 acre-feet and from applied water to be 22,100 acre-feet.

Groundwater discharge occurs as evapotranspiration, and pumpage. DWR (2004) estimated outflows include urban extraction at 3,900 acre-feet and agricultural extraction at 171,400 acre-feet.

Land Use

The Sutter subbasin is primarily utilized for fruit orchards, rice cultivation, and vegetable crops. There is a very little urban land use in the Sutter subbasin. Table 4-26 provides details on the distribution of land use throughout the subbasin.

Table 4-26. Land Uses in the Sutter Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Citrus and Subtropical	187	0.08
Deciduous Fruits and Nuts	45,556	19.44
Field Crops	38,226	16.31
Grain and Hay	11,676	4.98
Idle	3,400	1.45
Pasture	3,283	1.40
Rice	54,015	23.05
Semiagricultural and Incidental	1,744	0.74
Truck, Nursery, and Berry Crops	32,084	13.69
Vineyards	4	0.002
Subtotal	190,176	81.14
Urban		
Urban—unclassified	7,045	3.01
Commercial	209	0.09
Industrial	1,135	0.48
Urban Landscape	415	0.18
Urban Residential	1,412	0.60
Vacant	1,351	0.58
Subtotal	11,568	4.94
Native		
Riparian	8,507	3.63
Native Vegetation	19,570	8.35
Water	4,559	1.95
Subtotal	32,636	13.92
Total	**234,380**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The public entities within the Sutter subbasin aquifer system are: Sutter Mutual Water Company, Meridian Farms Water Company, Butte Slough Irrigation Company, Tisdale Irrigation District, Pelger Mutual Water Company, Sutter Extension Water District, Feather Water District, Oswald Water District, Tudor Mutual Water Company, Garden Highway Municipal Water Company (DWR 2004).

The private entities within the Sutter subbasin aquifer system are: Garden Highway Municipal Water Company, RD 70, RD 1660, RD 1500 (DWR 2004).

In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. RD 1500, South Sutter Water District, and Sutter Extension Water District have adopted groundwater management plans in accordance with AB 3030.

This subbasin falls within the area included in the Sacramento Valley Water Quality and Rice Coalitions.

Water Quality

Groundwater Quality issues in the Sutter subbasin include excess nutrients, dissolved solids, trace elements, and pesticides. Dissolved solids are elevated in localized areas throughout the subbasin and pesticides are persistent in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring but some are found at levels above the MCL's. Elevated nitrates are possibly due to on-site sewage systems (PMC 1996). However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the Sutter subbasin. Tables 4-27 and 4-28 summarize the available data.

Table 4-27. Water Quality in the Sutter Subbasin

Constituent of Concern	Available Information about groundwater concentrations for Sutter Subbasin
Nutrients	Nitrate concentrations greater than 45mg/L in localized areas (PMC 1996).
Pesticides (insecticides and herbicides) and degradation products	Bentazon and DBCP are present in groundwater (PMC 1996). Dawson (2001a) reported pesticides detections in 89% of the 28 wells sampled, 82% of which were pesticides used on rice fields: bentazon, carbofuran, molinate, and thiobencarb. Bentazon was found in 71% of the wells. Seven verified detections of simazine and 2 of bentazon in Sutter County from 1986 to 2003 (DPR 2004b).
Salt—primarily as electrical conductivity and total dissolved solids.	Dissolved solids exceed SMCL in 3 wells. Chloride exceeds 250 mg/L in a large area of the southeast section of the subbasin (PMC 1996). High TDS concentrations measured in shallow groundwater in rice growing areas. One well, south of Sutter Buttes, had a concentration of 8,730 mg/L of dissolved solids. (Dawson 2001a).
Trace elements	High concentrations of arsenic, boron, chloride, iron, and manganese. Manganese exceeds 50 µg/L in southern half and eastern boundary of Sutter County. Iron exceeds 300 µg/L in localized areas. Arsenic exceeds 10 µg/L to the south and east of Sutter Buttes and in other localized areas. Arsenic exceeds 50 µg/L in localized areas. (PMC 1996).
Microorganisms	No available data.
Volatile organic compounds	VOCs were detected in 12 of the 31 wells studied by Dawson (2001b).

Notes:

mg/L = milligrams per liter.

Sources: Dawson 2001b; Dawson 2001a; and PMC 1996.

Table 4-28. Concentrations of Constituents of Concern Detected in the Sutter Subbasin

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
Nutrients	Nitrate—Ammonia as N	0.02–0.46 mg/L	30 (HAL)
	Nitrate as N	0.06–12mg/L	10 (MCL[a])
	Nitrite as N	0.01–0.01 mg/L	1 (MCL[a])
	Orthophosphate, as P	0.01–0.4 mg/L	
	Phosphorus, as P	0.03–0.45 mg/L	
	Dissolved organic carbon, as C	0.2–6.8 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	0.001–0.026 µg/L	3 (MCL[a])
	Bentazon	0.02–7.8 µg/L	18 (MCL[b])
	Bromacil	0.34 µg/L (one detection)	90 (HAL)
	Desethyl atrazine	0.004–0.044 µg/L	
	Simazine	0.006–0.077 µg/L	4 (MCL[a])
	Tebuthiuron	0.32 µg/L (one detection)	500 (HAL)
Salt—primarily as electrical conductivity and total dissolved solids.		133–1,660 mg/L, (DWR 2004) 134–1,750 (Dawson 2001b)	500 (SMCL)
Inorganic Constituents			EPA Standard, 2000
	Arsenic	1–46 µg/L	50 (MCL[a])
	Bicarbonate	67–710 mg/L	
	Boron	12–110 µg/L	600 (HAL)
	Bromide	0.02–12 mg/L	
	Calcium	10–810 mg/L	
	Chloride	2.0–4,800 mg/L	250 (SMCL)
	Fluoride	0.1–1.8 µg/L	4 (MCL[a])
	Iron Fe	3–1,600 µg/L	300 (SMCL)
	Magnesium	5.0–480 mg/L	
	Manganese	1–870 µg/L	50 (SMCL)
	Potassium	0.40–9 mg/L	
	Silica	16–86 mg/L	
	Sodium	5.7–1,300 mg/L	
	Sulfate	1.0–1,500 mg/L	250 (SMCL)
	Total Hardness as $CaCO_3$	48 (soft)–940 mg/L (very hard), median is 135 mg/L	
Organic carbon and disinfection byproduct precursors	DOC	0.2–0.7 mg/L, median 0.3 mg/L	
Volatile organic compounds*	1,1-Dichloroethane	*0.02*–0.04 µg/L	
	1,2,4-Trimethylbenzene	*0.01*–0.02 µg/L	
	1,2-Dichloroethane	0.19 µg/L	0.5 (MCL[a])
	Bromodichloromethane	*0.03* µg/L	100 (MCL[a])
	cis-1,2-Dichloroethene	0.43 µg/L	6 (MCL[b])
	Dichlorodifluoromethane	*0.04*–0.29 µg/L	1000 (HAL)

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
	Methyl tert-butyl ether	*0.06* µg/L	20 (HAL)
	Styrene	*0.06* µg/L	100 (MCL[a])
	Tetrachloroethene	0.58–0.97 µg/L	5 (MCL[a])
	Tetrachloromethane	1.2 µg/L	0.5 (MCL[b])
	Trichloroethene	*0.01*–5.5 µg/L	5 (MCL[a])
	Trichlorofluoromethane	*0.04* µg/L	150 (MCL[b])
	Trichloromethane	*0.03*–1.1 µg/L	100 (MCL[a])

Notes:
* Numbers in *italics* are estimates.
MCL[a] = Maximum Contaminant Level set by EPA (2005).
MCL[b] = Maximum Contaminant Level set by DWR.
µg/l = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
HAL = Health Advisory Level set by EPA (2005).
Sources: Dawson 2001a, 2001b, unless otherwise indicated.

Nutrients

Dawson (2001a) presented evidence for movement of nitrate to shallow groundwater in rice growing areas. Specifically, she demonstrated a significant correlation of nitrate concentrations with groundwater depth—higher nitrate concentrations were associated with shallower groundwater depths indicating movement of nitrate from land surface associated with agricultural activities. There are naturally occurring nitrates in some formations of the Sacramento Valley. However, most nitrogen species that occur above 3 mg/L signify contamination introduced into the groundwater via human activates such as agriculture and urbanized development. At this time, the data available for the Southeastern Sacramento Valley, an area that includes the Sutter subbasin, show that 8 of the 31 wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The central flood plains, in which Sutter subbasin is located, contain a mixture of magnesium-calcium-carbonate groundwater (common in the eastern alluvial plain) and sodium-sulfate groundwater (common in the western alluvial plain. Two processes appear to primarily affect groundwater salinity in the Sutter subbasin: evaporation of irrigation water and shallow groundwater and mixing of naturally occurring saline groundwater (Hull 1984, Olmsted and Davis 1961, Dawson 2001b). Using isotope data, Dawson (2001a) presented evidence that partial evaporation accounted for some of the measured increase in salinity among shallow groundwater samples.

One well located south of the Sutter Buttes yields groundwater of the sodium-calcium type. This same well had a concentration of 8,730 mg/L dissolved solids in the 1997 study by Dawson (2001a).

Pesticides

Rice pesticides Molinate, Thiobencarb, and Carbofuran were detected in 7, 3, and 4 of the 28 wells sampled during the 1997 study by the USGS (Dawson 2001a). The most prevalent pesticide detected in groundwater was bentazon. This chemical was used in rice fields until it was suspended in 1989 and officially banned in 1992. Its presence in groundwater in studies completed in 1997 (Domagalski et al. 2000) suggests it is readily transported in groundwater and does not degrade quickly. Although present in most wells in the rice growing areas of the Sacramento Valley in the 1997 Dawson study, pesticide concentrations were only detected in one well in the Sutter subbasin in the 1996 Dawson study (Dawson 2001b). This well was located adjacent to and southeast of the Sutter Buttes. Two different pesticides were present in this domestic well at concentrations below the drinking water limits.

Trace Elements

The chemistry of geology formations in the Sutter subbasin influences the concentrations of trace elements. Dawson (2001a) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and zinc. Concentrations of silica were significantly higher in the eastern alluvial plain, which contains part of the Sutter subbasin. Concentrations of arsenic and potassium were significantly higher in the central flood basins, which are also part of the Sutter subbasin. Dawson (2001b) presented evidence that the presence and concentration of arsenic is related to the dissolved oxygen concentration (or redox condition) of the groundwater. As the concentration of dissolved oxygen increases, the arsenic concentrations decrease. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Vina Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Vina Subbasin is bounded on the west by the Sacramento River, on the north by Deer Creek, on the east by the Chico Monocline and on the south by Big Chico Creek. Deer Creek and Big Chico Creek serve as hydrologic boundaries in the near surface. The subbasin is contiguous with the Los Molinos and West Butte subbasins at depth. The subbasin is 125,600 acres (195 square miles) in size and is located in parts of Butte and Tehama Counties.

The following description of the hydrogeology in the Vina subbasin is taken from DWR Bulletin 118 (DWR 2004).

The aquifer system is comprised of continental deposits of Tertiary to late Quaternary age. The Quaternary deposits include Holocene stream channel deposits and Pleistocene Modesto Formation deposits, located along most stream and river channels, and alluvial fan deposits. The Tertiary deposits include the Tuscan Formation.

Holocene Stream Channel deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Tuscan Formation and Quaternary stream terrace alluvial deposits. The thickness varies from 1 to 80 feet. The unit represents the upper part of the unconfined zone of the aquifer and is moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

Holocene Basin deposits are the result of sediment-laden floodwaters that rose above the natural levees of streams and rivers to spread across low-lying areas. They consist primarily of silts and clays and may be locally interbedded with stream channel deposits along the Sacramento River. Thickness of these deposits can range up to 150 feet and they are observed primarily between Mud Creek and Rock Creek, west of Highway 99. These deposits have low permeability and generally yield low quantities of poor quality water to wells.

The Pleistocene Modesto Formation consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tuscan Formation and Riverbank Formation. The Modesto Formation makes up the majority of the alluvial plain deposits except where older Riverbank Formation terrace deposits occur south of Pine Creek and the overlying basin deposits in the Nord area predominate. Thickness of the formation can range from less than 10 feet to nearly 200 feet across the valley floor.

The Pleistocene Riverbank Formation (older terrace deposits) consists of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. These deposits underlie the region between Pine Creek and Rock Creek. Thickness of the formation can range from less than 10 feet to nearly 200 feet across the valley floor.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subbasin and extend in the subsurface west of the Sacramento River.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B. Unit C is exposed as alluvial upland deposits west of the Chico Monocline, largely north of Singer Creek. South of Singer Creek, the alluvial upland deposits merge with younger alluvial fan and plain deposits.

The Tuscan Formation reaches a thickness of 1,250 feet over older sedimentary deposits. The dip of the formation averages approximately 2.5 degrees, east of the valley, and steepens sharply to 10 to 20 degrees southwestward towards the valley at the Chico Monocline. The formation flattens beneath valley sediments.

Groundwater levels in the northern part of the Butte County show a decline because of the 1976–1977 and 1987–1994 droughts, followed by a recovery of groundwater levels to pre-drought conditions. Year-round extraction of groundwater for municipal use in the Chico area causes several small groundwater depressions that tend to alter the natural southwesterly movement of groundwater in the area. In the Chico area, groundwater level fluctuation in the unconfined portion of the aquifer system is about 5–7 feet during normal precipitation and up to approximately 16 feet during periods of drought. Annual fluctuation in the confined or semi-confined portion of the aquifer system is approximately 15–25 feet during normal years and up to approximately 30 feet during periods of drought. Groundwater levels for the confined or semi-confined portions of the aquifer system indicate a 10–15-foot decline in groundwater levels since the 1950s.

Groundwater storage capacity was estimated to be 1,468,000 acre-feet. This estimate was based on an average specific yield of 5.9% and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from local precipitation (18–22.5 inches/year), subsurface flow from the Sierra Nevada and foothills, irrigation infiltration, and stream infiltration. Source water for irrigation is a mix of surface and groundwater. Natural recharge takes place along streams and outcrops of the Tuscan Formation to the east of the study area. Sources of non-natural uncontrolled recharge include leakage from pipelines, seepage through the boundaries of the groundwater basin, and most significantly, net irrigation return flows. The Chico Monocline forms a geographic boundary; however, a component of basin recharge is located east of the fault structure.

In an isotopic study of shallow monitoring wells on the east side of the Sacramento Valley, Moran et al. (2004) presented evidence of recent recharge of the Vina groundwater basin from flood irrigation. This study also found that Big Chico Creek significantly recharges the aquifer from the south and groundwater in the Chico area originates in the Sacramento Valley. Tritium concentrations in this same study indicate a pre-1950 recharge date for the groundwater located north of Big Chico Creek.

Estimate of groundwater extraction for agricultural use is estimated to be 130,000 acre-feet. Municipal and industrial use is approximately 20,000 acre-feet. Deep percolation of applied water is estimated to be 30,000 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 37% of the subbasin, urban land use accounts for about 8% of the subbasin, and native land accounts for about 55% of the subbasin. Of the agricultural land uses, deciduous fruits and nuts make up 29%. Table 4-29 provides details of the land uses within the subbasin.

Table 4-29. Land Use in the Vina Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	400	0.30
Deciduous Fruits and Nuts	36,000	28.90
Field Crops	3,940	3.20
Grain and Hay	2,300	1.80
Pasture	1,900	1.50
Truck, Nursery, and Berry Crops	180	0.10
Idle	1,130	0.90
Semiagricultural and Incidental	570	0.50
Subtotal	46,420	37.20

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Urban—unclassified	5,100	4.10
Urban Landscape	390	0.30
Urban Residential	3,190	2.60
Commercial	300	0.20
Industrial	300	0.20
Vacant	650	0.50
Subtotal	9,930	8.00
Native		
Native Vegetation	64,300	51.50
Barren and Wasteland	230	0.20
Riparian	2,650	2.10
Water	1,220	1.00
Subtotal	68,400	54.80
Total	**124,750**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Vina groundwater subbasin is within the Shasta-Tehama Watershed. The public agencies within the Vina subbasin are: Butte Basin Water User Association, Deer Creek ID, Stanford Vina Ranch ID, City of Chico, Tehama County Flood Control and Conservation District. Groundwater management ordinances were adopted in Butte County in 1996 and in Tehama County in 1994. The Butte County ordinance requires export permits for groundwater extraction and substitute pumping, establishes the Water Commission and Technical Advisory Committee, and provides countywide groundwater monitoring programs. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use and influence of well pumping restrictions. The city of Chico is located partly within the subbasin, on the southern edge. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. TDS ranges from 48 to 543 mg/L, averaging 285 mg/L. Groundwater quality issues include localized high calcium and nitrate, TDS and VOCs in the Chico area.

Nitrate

A common water quality problem in several of the subbasins, including Vina, is nitrate contamination by septic leachate and by agricultural activities. Nitrate exceeded the MCL in 4 public supply wells in the Vina subbasin. Nitrate contamination was more commonly found in shallow private wells rather than in the long-screened production wells included in the GAMA study by Moran et al. (2004).

Volatile Organic Compounds

According to the CDPH database, only 4 public wells had had detections of VOCs above MCLs from 1994 through 2000 and none have had MTBE concentrations above the detection limit for reporting for California Code of Regulations Title 22 water (5 parts per billion [ppb]).

More recently, tetrachloroethylene (also known as perchloroethylene, PCE) was detected in 47 public supply wells in the Chico area; all but 4 detections were at concentrations well below the MCL, which is 5,000 ng/L, and 16 were below the public health goal (PHG) of 56 ng/L. The Chico area also has a widespread contaminant plume of PCE. PCE is a solvent used in dry cleaning and metal cleaning operations. Nineteen of the Chico wells with PCE detections also had detections of trichloroethylene (TCE), which likely occurs as a breakdown product. MTBE co-occurred with PCE even more frequently, with 33 PCE-contaminated wells also having MTBE detections, suggesting a high degree of vulnerability to both recently introduced and decades-old contaminants at those wells. Groundwater contamination with VOCs does not appear to be related to irrigated agriculture. (Moran et al. 2004.)

West Butte Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The West Butte subbasin aquifer is part of the Sacramento Valley groundwater basin. It is bound by Big Chico Creek on the north, the Sacramento River on the south and west, by the Chico Monocline on the northeast and by Butte Creek on the east. The aquifer system is 284 square miles in size and is located in parts of Butte, Glenn, and Colusa Counties.

The following description of the hydrogeology in the West Butte subbasin is taken from DWR Bulletin 118 (2004).

The West Butte aquifer system is comprised of deposits of Late Tertiary to Quaternary age. The Quaternary deposits include the Holocene stream channel deposits and basin deposits, and the Pleistocene Modesto Formation, Riverbank Formation, and Sutter Buttes alluvium. The Tertiary deposits consist of the Pliocene Tehama Formation and the Tuscan Formation.

These deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Quaternary stream terrace alluvial deposits. The thickness varies from 1 to 80 feet. The unit represents the upper part of the unconfined zone of the aquifer and is moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

Basin deposits are the result of sediment-laden floodwaters that rose above the natural levees of streams and rivers to spread across low-lying areas. They consist primarily of silts and clays and may be locally interbedded with stream channel deposits along the Sacramento River. The deposits extend from south of Big Chico Creek to north of Angel Slough. Thickness of the unit can range from 10 to 100 feet (DWR 2001). The deposits have low permeability and generally yield low quantities of water to wells. The quality of groundwater produced from the unit is often poor (Reclamation 1960).

The Modesto Formation (deposited between 14,000 and 42,000 years ago) consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tuscan and Riverbank formations. Surface exposures extend south from Big Chico Creek to north of the city of Durham and extend south of Angel Slough to the Sacramento River. The unit varies in thickness from 50 to 150 feet (DWR 2000). In locations where gravel and sand predominate, groundwater yields are moderate.

The Riverbank Formation (deposited between 130,000 and 450,000 years ago) consists of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. The areal extent of the formation is limited more to the southern portion of the subbasin and underlies surface exposures of the Modesto Formation. The thickness of the formation is approximately 1–200 feet depending on location (DWR 2000). The formation is moderately to highly permeable and yields moderate quantities of water to domestic and shallow irrigation wells.

In the southern extents of the subbasin, Sutter Buttes alluvium is observed in the subsurface and may range in thickness up to 600 feet (DWR 2000). These alluvial fan deposits consist largely of gravel, sand, silt, and clay and may extend up to 15 miles north of the Sutter Buttes and westerly beyond the Sacramento River. Utility pump test records for wells located east of the subbasin, but believed to be in the same formation, show the average well yield for the formation to be approximately 2,300 gpm with an average specific capacity of 64 gpm/ft.

The Tehama Formation consists of sediments originating from the coastal mountains and interfingers with sediments of the Tuscan Formation in the vicinity of the Sacramento River at the far western extent of the subbasin (DWR 2000).

The Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. Thickness of the formation is estimated to be 800 feet. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subsurface in the northern part of the subbasin and Units A and B are found in the southern part of the subbasin. Surface exposures of Units A, B, and C are located in the foothills at the far eastern extents of the subbasin. The surface exposure of Unit B east of the subbasin boundary is a recharge area. Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit B is olcaniclastic and is the most transmissive portion of the volcanic aquifer system and is the primary aquifer at depth. The surface exposure of Unit B, east of the subbasin boundary, is a recharge area. Although the Tuscan Formation is unconfined where it is exposed near the valley margin, at depth, the formation is confined. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable underlying sediments of Unit B.

Groundwater levels in the West Butte subbasin tend to fluctuate by 5 feet in normal and dry years. There is no consistent decreasing trend in the aquifer levels. DWR (2004) estimated the specific yield to by 7.1% and the storage capacity (to a depth of 200 feet) to be 13 maf.

Major Sources of Recharge

Irrigation is the primary source of groundwater recharge to the subbasin. Regionally, stream infiltration and, to a lesser extent precipitation, are also sources of recharge. Big Chico Creek, Little Chico Creek, and Butte Creek are major streams entering the subbasin. The Sacramento River drains the subbasin. Annual precipitation ranges from 17 to 27 inches with higher precipitation occurring to the west. Almost 30% of land is used for rice cultivation where the fields are typically flooded for 6 months each year. Groundwater discharge occurs as evapotranspiration, loss to streams, and pumpage. Almost all the water used for irrigation in the West Butte subbasin is pumped from groundwater.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1998–1999. The West Butte subbasin is primarily utilized for agricultural purposes with rice fields and orchards covering the highest percentage of land. Table 4-30 provides details on the distribution of land use throughout the West Butte subbasin.

Table 4-30. Land Uses in the West Butte Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Citrus and Subtropical	131	0.07
Deciduous Fruits and Nuts	37,122	20.43
Field Crops	19,309	10.63
Grain and Hay	9,466	5.21
Idle	2,093	1.15
Pasture	4,817	2.65
Rice	52,971	29.16
Semiagricultural and Incidental	563	0.31
Truck, Nursery, and Berry Crops	2,564	1.41
Subtotal	129,036	71.03
Urban		
Urban—unclassified	2,065	1.14
Commercial	463	0.25
Industrial	529	0.29
Urban Landscape	160	0.09
Urban Residential	1,461	0.80
Vacant	951	0.52
Subtotal	5,629	3.10
Native		
Riparian	25,149	13.84
Native Vegetation	16,261	8.95
Water	5,062	2.79
Barren and Wasteland	532	0.29
Subtotal	47,004	25.87
Total	**181,669**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The public entities within the West Butte subbasin aquifer system are: Butte Basin Water Users Association, Buzztail Community Service District, Durham ID, City of Chico, RD 1004, Western Canal WD, M&T Chico Ranch Inc., Sartain MWC (DWR 2004).

The private entities within the West Butte subbasin aquifer system are: Dayton Mutual Water Company, Del Oro Water Company, Durham Mutual Water Company, and California Water Service (DWR 2004).

Butte County adopted a groundwater management ordinance in 1996. Glenn County adopted a groundwater management ordinance in 2000. Colusa County adopted a groundwater management ordinance in 1998 (DWR 2004). These ordinances affect primarily the volume of groundwater that can be pumped in the subbasin. Additionally, the Butte County and Glenn County ordinances established Water Commissions and Technical Advisory Committees and countywide monitoring plans.

This subbasin falls within the area included in the Sacramento Valley and Rice Water Quality Coalitions.

Water Quality

Groundwater quality issues in the West Butte subbasin include excess nutrients, dissolved solids, trace elements, and pesticides. Dissolved solids are elevated in localized areas throughout the subbasin and pesticides are persistent in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring, as well as nitrates in some locations. However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the West Butte subbasin (Dawson 2001a). Tables 4-31 and 4-32 summarize the available data.

Table 4-31. Water Quality in the West Butte Subbasin

Constituent of Concern	Available Information about groundwater concentrations for West Butte Subbasin
Nutrients	Median NO_3 concentration under rice fields was 2 mg/L (Domagalski et al. 2000). Nitrate, ammonia, phosphorus measured in shallow groundwater in rice growing areas (Dawson 2001a).
Pesticides (insecticides and herbicides) and degradation products	Dawson (2001a) reported pesticides detections in 89% of the 28 wells sampled, 82% of which were pesticides used on rice fields: bentazon, carbofuran, molinate, and thiobencarb. Bentazon was found in 71% of the wells.
Salt—primarily as electrical conductivity and total dissolved solids.	Localized high EC, TDS, and adjusted sodium absorption ratio (ASAR) (DWR 2004). High TDS concentrations measured in shallow groundwater in rice growing areas (Dawson 2001a).

Constituent of Concern	Available Information about groundwater concentrations for West Butte Subbasin
Trace elements	Localized high calcium, EC, boron (DWR 2004). Dawson (2001a) found concentrations of inorganic constituents that exceeded primary state and federal drinking water standards at least once in 25% of the wells. The inorganic constituents detected above the primary limits were boron, barium, cadmium, molybdenum, or sulfate. Secondary drinking water standards were exceeded at least once in 79% of the wells. The constituents detected above secondary limits were chloride, iron, manganese, specific conductance (EC), or dissolved solids.
Organic carbon and disinfection byproduct precursors	Dissolved organic carbon elevated relative to expected background in some areas (Dawson 2001a).
Microorganisms	No available data.
Volatile organic compounds	One public supply well out of 26 sampled has concentrations above MCL (DWR 2004). According to the CDPH database, one public well had detections of VOCs above MCLs from 1994 to 2000 (Lawrence Livermore National Laboratory GAMA Study [Moran et al. 2004]).

Notes:
mg/L = milligrams per liter.

Table 4-32. Concentrations of Constituents of Concern Detected in the West Butte Subbasin

Constituent Type	Constituent of Concern	Concentration ranges	Drinking Water Standards
Nutrients	Nitrate	Median 2 mg/L (Domagalski et al. 2000)	Nitrate was reported to exceed the MCL in two public supply wells in the West Butte subbasin (Moran et al. 2004).
	Ammonia as N	0.02–0.46 mg/L	30 (HAL)
	Ammonia + organic N as N	0.3–0.7 mg/L	30 (HAL)
	Nitrate+Nitrite, as N	0.08–6.2 mg/L	10 (MCL)
	Nitrate as N	0.08–6.2 mg/L	10 (MCL)
	Nitrite as N	0.01–0.1 mg/L	1 (MCL)
	Orthophosphate, as P	0.01–0.36 mg/L	
	Phosphorus, as P	0.03–0.362 mg/L	
	Dissolved organic carbon, as C	0.3–6.8 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	*0.002*–0.026 µg/L	3 (MCL)
	Bentazon	0.06–*7.8* µg/L	18 (MCL)
	Bromacil	0.19min µg/L	90 (HAL)
	Carbofuran	0.016–0.8 µg/L	18 (MCL)
	Desethyl atrazine	0.001–0.005 µg/L	
	Dichlorprop	0.1min µg/L	
	Diuron	0.04–0.09 µg/L	10 (HAL)

Constituent Type	Constituent of Concern	Concentration ranges	Drinking Water Standards
	Azinphos-methyl	0.014min µg/L	
	Molinate	*0.002*–0.056 µg/L	20 (MCL)
	Simazine	*0.002*–0.027 µg/L	4 (MCL)
	Tebuthiuron	0.006min µg/L	500 (HAL)
	Thiobencarb	0.006–0.025 µg/L	70 (MCL)
Salt—primarily as electrical conductivity and total dissolved solids.		120–1,220 mg/L, mean 391 mg/L (DWR 2004) 168–8,730 mg/L, median 532 mg/L (Dawson 2001a)	
Trace elements	Aluminum	0.002–0.010 mg/L	1 (MCL)
	Arsenic	0.001–0.015 mg/L	0.01 (MCL)
	Barium	0.01–5.05 mg/L	1(MCL)
	Boron	0.02–1.8 mg/L	0.6 (HAL)
	Bromide	0.03–12 mg/L	
	Cadmium	0.006–0.007 mg/L	0.005 (MCL)
	Chromium	0.002–0.016 mg/L	0.05 (MCL)
	Cobalt	0.001–0.004 mg/L	
	Copper	0.001–0.003 mg/L	1.3 (MCL)
	Ferrous Iron Fe^{2+}	Detected in 19/28 wells	
	Fluoride	0.1–1.8 mg/L	4 (MCL)
	Iron Fe	0.003–5.3 mg/L	0.3 (SMCL)
	Manganese	0.05–0.1 mg/L	0.05 (SMCL)
	Molybdenum	0.001–0.051 mg/L	0.04 (HAL)
	Nickel	0.001–0.009 mg/L	0.1 (HAL)
	Selenium	0.003–0.022 mg/L	0.05 (MCL)
	Sulfide	Detected in 14/28 wells	
	Uranium	0.001–0.023 mg/L	2000 (MCL)
	Zinc	0.001–0.017 mg/L	2 (HAL)

Notes:
* Numbers in *italics* are estimates.
MCL = Maximum Contaminant Level set by EPA (2005).
µg/l = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
HAL = Health Advisory Level set by EPA (2005).
Sources: Dawson 2001a, 2001b, unless otherwise indicated.

Nutrients

MCL exceedances of nitrate are reported in 4 public supply wells in the subbasin. Nitrate contamination is more commonly found in shallow private wells rather than in the long-screened production wells included in this study.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The geochemical facies of the groundwater in the West Butte subbasin in a mix of the calcium-magnesium bicarbonate waters in the western alluvial fan and the sodium sulfate waters in the eastern alluvial fan. Two processes appear to primarily affect groundwater salinity in the West Butte subbasin: evaporation of irrigation water and shallow groundwater and mixing of naturally occurring saline groundwater (Hull 1984, Olmsted and Davis 1961, Dawson 2001a). Using isotope data, Dawson (2001a) presented evidence that partial evaporation as indicated by the isotope data accounted for some of the measured increase in salinity among shallow groundwater samples.

Pesticides

Rice pesticides Molinate, Thiobencarb, and Carbofuran were detected in 7, 3, and 4 of the 28 wells sampled during the 1997 study by the USGS (Dawson 2001a). The most prevalent pesticide detected in groundwater was bentazon. This chemical was used in rice fields until it was suspended in 1989 and officially banned in 1992. Its presence in groundwater in studies completed in 1997 (Domagalski et al. 2000) suggests it is readily transported in groundwater and does not degrade quickly. Although present in many wells in the rice growing areas of the West Butte subbasin, pesticide concentrations were below state and federal 2000 drinking water standards in all occurrences.

Dawson (2001a) investigated the relationship between groundwater quality and rice cultivation land use practices in data collected during 1998. Dawson (2001a) found that shallower groundwater had more occurrences of pesticide contamination than deeper groundwater, indicating the movement of pesticides from the ground surface downward. Concentrations of bentazon showed a statistical relationship to tritium concentrations. Since tritium is used for age-dating groundwater, this relationship suggests that bentazon concentrations may be related to recharge age of the groundwater in which it was found. Tritium concentrations in all wells except one indicate that groundwater in the rice growing areas of the West Butte subbasin were recharged after 1950. To further identify the date at which the pesticides entered groundwater, the first application dates of the pesticides in the Sacramento Valley were studied. This resulted groundwater recharge dating in the late 1970s.

Irrigation practices can affect the amount of pesticides that reach groundwater. Troiano et al. (1993) investigated difference irrigation methods and found that "leaching of pesticides was less in sprinkler applications because water was applied more frequently in smaller applications than for the basin-flooding method. For basin-flooding treatments, as those practiced on rice fields, a large amount of water application was required for each irrigation in order to provide application across the plot. Although irrigations were less frequent, the larger water volume caused greater downward movement of water and atrazine residues."

Trace Elements

The chemistry of geology formations in the West Butte subbasin influences the concentrations of trace elements. Dawson (2001a, 2001b) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and zinc. Concentrations of arsenic and potassium were significantly higher in wells in the central flood basin, which contains the West Butte subbasin. Concentrations of nitrate were significantly lower in the central flood basin. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Volatile Organic Compounds

According to the CDPH database, only 4 public wells had had detections of VOCs above MCLs from 1994 to 2000 and none have had MTBE concentrations above the detection limit for reporting for Title 22 water (5 ppb).

Yolo Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Yolo subbasin aquifer is bound by Cache Creek in the north, Putah Creek in the south, the Coast Ranges on the west, and the Sacramento River on the east. The aquifer system is 400 square miles in size and is located in parts of Yolo and Solano Counties. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The primary water bearing formations comprising the Yolo subbasin are sedimentary continental deposits of Late Tertiary (Pliocene) to Quaternary (Holocene) age. Fresh water-bearing units include younger alluvium, older alluvium, and the Tehama Formation. The cumulative thickness of these units ranges from a few hundred feet near the Coast Ranges on the west to nearly 3,000 feet near the eastern margin of the basin. Saline water-bearing sedimentary units underlie the Tehama formation and are generally considered the boundary of fresh water.

Younger alluvium includes flood basin deposits and recent stream channel deposits. Flood basin deposits occur along the eastern margin of the subbasin in the Yolo Flood Basin. They consist primarily of silts and clays, but along the eastern margin of the subbasin may be locally interbedded with stream channel deposits of the Sacramento River. Thickness of the unit ranges from 0 to 150 feet. The flood basin deposits have low permeability and generally yield low quantities of water to wells. The quality of groundwater produced from the basin deposits is often poor.

Recent stream channel deposits consist of unconsolidated silt, fine- to medium-grained sand, gravel and occasionally cobbles deposited in and adjacent to active streams in the subbasin. They occur along the Sacramento River, Cache Creek, and Putah Creek. Thickness of the younger alluvium ranges from 0 to 150 feet.

The younger alluvium varies from moderately to highly permeable, but often lies above the saturated zone. Where saturated, the younger alluvium yields significant quantities of water to wells.

Older alluvium consists of loose to moderately compacted silt, silty clay, sand, and gravel deposited in alluvial fans during the Pliocene and Pleistocene. Thickness of the unit ranges from 60 to 130 feet, about one-quarter of which is coarse sand and gravel. Permeability of the older alluvium is highly variable. Wells penetrating sand and gravel lenses of the unit produce between 300 and 1,000 gpm. Adjacent to the Sacramento River, wells completed in ancestral Sacramento River stream channel deposits yield up to

4,000 gpm. Wells completed in the finer-grained portions of the older alluvium produce between 50 and 150 gpm.

The Tehama Formation is the thickest water-bearing unit underlying the Yolo subbasin, ranging in thickness from 1,500 to 2,500 feet. Surface exposures of the Tehama Formation are limited mainly to the Coast Range foothills along the western margin of the basin, as well as in the Plainfield Ridge. The Tehama consists of moderately compacted silt, clay, and silty fine sand enclosing lenses of sand and gravel, silt and gravel, and cemented conglomerate. Permeability of the Tehama Formation is variable, but generally less than the younger units. Because of its relatively greater thickness, however, wells completed in the unit can yield up to several thousand gallons per minute.

Underlying the Tehama Formation are brackish to saline water-bearing sedimentary units, including the somewhat brackish sedimentary rocks of volcanic origin (Pliocene to Oligocene?) underlain by marine sedimentary rocks (Oligocene? to Paleocene) which are typically of low permeability and contain connate water. The upper contact of these units generally coincides with the fresh/saline water boundary. The contact is found near the Coast Range at depths as shallow as a few hundred feet. Near the eastern margin of the basin it reaches depths of nearly 3,000 feet.

The geologic structure of the groundwater subbasin is dominated by an anticlinal ridge oriented northwest to southeast, which is expressed at the surface as the Dunnigan Hills and Plainfield Ridge. The anticlinal structure impedes subsurface flow from west to east. Subsurface groundwater outflow sometimes occurs from the Yolo subbasin into the Solano subbasin to the south. Subsurface outflow and inflow may also occur beneath the Sacramento River to the east with the South and North American subbasins. Subsurface groundwater inflow may occur from the west out of the Capay Valley Basin.

DWR (2004) estimated the specific yield to be 6.5 to 9.7% and the storage capacity (20–400 feet) to be approximately 6.5 maf.

Major Sources of Recharge

Irrigation is the primary source of groundwater recharge to the subbasin. Regionally, stream infiltration and to a lesser extent precipitation are also sources of recharge. Major streams above the Yolo subbasin are Cache Creek, Putah Creek, and the Sacramento River. Annual precipitation ranges from 18 to 24 inches with higher precipitation occurring to the west. Groundwater discharge occurs as evapotranspiration, loss to streams, and pumpage.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land use accounts for about 69% of the subbasin, urban land use accounts for about 12% of the subbasin, and native land accounts for about 19% of the subbasin. Table 4-33 provides details on the distribution of land use throughout Yolo Subbasin.

Table 4-33. Land Use in the Yolo Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	226	0.10

Land Use	Acreage of Land Use	Percent of Land Use
Deciduous Fruits and Nuts	11,359	5.03
Field Crops	41,426	18.34
Grain and Hay	33,421	14.80
Idle	4,807	2.13
Pasture	22,609	10.01
Rice	12,951	5.73
Semiagricultural and Incidental	1,714	0.76
Truck, Nursery, and Berry Crops	26,372	11.68
Vineyards	360	0.16
Subtotal	155,244	68.74
Urban		
Urban—unclassified	13,606	6.02
Commercial	1,216	0.54
Industrial	4,625	2.05
Urban Landscape	1,178	0.52
Urban Residential	2,546	1.13
Vacant	4,223	1.87
Subtotal	27,393	12.13
Native		
Barren and Wasteland	534	0.24
Riparian	2,702	1.20
Native Vegetation	37,251	16.49
Water	2,724	1.21
Subtotal	43,211	19.13
Total	**225,848**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The public entities within the Yolo subbasin aquifer system are: Yolo County Flood Control and Water Conservation District, City of Woodland, City of Davis, City of West Sacramento (DWR 2004). The private entities within the Yolo subbasin aquifer system are RDs 108, 900, 2035, and 2068 (DWR 2004).

In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. RD 108 adopted an AB 3030 plan in February 1995. RD 2035 adopted an AB 3030 plan in April 1995. RD 2068 adopted an AB 3030 plan in January 1997. Yolo County Flood Control and Water Conservation District is drafting a plan but it is not pursuant to AB 3030.

This subbasin falls within the area included in the Sacramento Valley and Rice Water Quality Coalitions.

Water Quality

Groundwater Quality issues in the Yolo subbasin include high dissolved solids, boron, selenium and nitrate. Hardness, which is mainly a reflection of the amount of calcium and magnesium in water, is considered very high, with values generally greater than 180 mg/L (Evenson 1984).

High average concentrations of dissolved solids, calcium, magnesium, sodium, chloride, and fluoride exist in the alluvial fans adjacent to the Coast Range in the southwestern margin of the Sacramento Valley. Boron and bicarbonate concentrations are very high. Silica concentrations are generally low. TDS measured in wells in this area show trends of significant increase in dissolved solids since the 1950s, while wells measured for nitrates showed no significant change over time (Hull 1984). Groundwater to the west of the Sacramento River in Yolo County is recharged by eastward flowing streams that drain the marine sediments to the west. This water is predominantly magnesium and magnesium-sodium bicarbonate and is of poorer quality than Sacramento Valley Basin water derived from the east (DWR 1974).

A USGS study (Evenson 1985) analyzed water quality in the Solano and Yolo Counties. Constituents that were measured include: dissolved solids, harness, chloride, fluoride, sulfate, nitrogen, arsenic, boron, iron, and manganese. Except where otherwise noted, the following is a summary of the findings as they pertain to the Yolo subbasin.

Using stable isotope data, Davisson and Criss (1993) elucidated the processes influencing increasing groundwater salinity in the Davis area. Specifically, their data supported the hypothesis of higher salinity groundwater within about 240 feet of land surface could be attributed to infiltration of irrigation water. The increased isotopic enrichment of this groundwater indicated soil evaporation associated with irrigated agriculture. This isotopic enrichment was also associated with high nitrate concentrations indicating fertilization influence.

Pesticides

According to DPR (2004), for the period of 1985 to 2003, atrazine, bentazon, and simazine were detected in Yolo County. Sampling locations and concentrations were not specified.

Nitrogen

Nitrogen concentrations varied over the subbasin, with some domestic wells sampled having concentrations above the EPA limit of 10 mg/L nitrate-nitrogen. The maximum concentration was 24 mg/L.

Boron

Boron concentrations were greater than 0.75 mg/L from Zamora to Knights Landing. High boron concentrations were generally found in water sampled from wells near Cache Creek; this indicates that surface water from the creek may be a source for high boron levels in the surrounding groundwater.

Arsenic

Arsenic concentrations are less than the EPA primary drinking water regulated limit of 0.05 ppm. The highest concentrations are along the northern and eastern margins of the Yolo subbasin.

Iron

Iron concentrations are generally low with respect to federal standards (MCL = 0.3 ppm) in the Yolo subbasin. Along the Cache Creek and in the eastern part of the study area, values ranged form 0.02 to 0.49 mg/L. In other areas, all wells sampled contained less than 0.02 mg/L.

Manganese

Groundwater sampled near the Sacramento River in the southeastern part of the subbasin had the highest concentrations of manganese (greater than 0.1 mg/L), with concentrations decreasing as a function of distance from the river. Wells sampled in the western half of the Yolo subbasin had levels generally below 0.01 mg/L. The MCL (as a secondary constituent) for manganese is 0.05 ppm.

South Fork Pit River Subbasin—Alturas Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The South Fork Pit River groundwater subbasin is located in Lassen and Modoc Counties and is 114,000 acres (178 square miles) in size. It is bounded on the east by Plio-Pleistocene basalt and Pleistocene Pyroclastic rocks of the Warner Mountains, to the north by Pleistocene basalt of Devils Garden, to the south by Plio-Pleistocene basalt, and to the west by Warm Springs tuff. The South Fork Pit River enters the subbasin near the community of Likely and flows north through the South Fork Pit River Valley to its confluence with the North Fork Pit at the town of Alturas.

The following description of the hydrogeology in the South Fork Pit River subbasin is taken from DWR Bulletin 118 (DWR 2004).

The principal water-bearing formations are Holocene sedimentary deposits (which include alluvial fan deposits, intermediate alluvium, and basin deposits), Pleistocene lava flows and near-shore deposits, and Plio-Pleistocene Alturas Formation and basalts.

The Holocene sedimentary deposits include alluvial fan deposits, intermediate alluvium, and basin deposits—each up to a thickness of 75 feet. Alluvial fan deposits consist of unconsolidated to poorly consolidated, crudely stratified silt, sand and gravel with lenses of clay. These deposits generally have high permeability and are capable of yielding large amounts of water to wells. This unit may include confined as well as unconfined water.

Intermediate alluvium consists of unconsolidated poorly sorted silt and sand with some lenses of gravel. These deposits have moderate permeability and yield moderate amounts of water to shallow wells.

Basin deposits consist of unconsolidated, interstratified clay, silt, and fine sand. These deposits have moderate to low permeability and yield small amounts of water to wells.

The Pleistocene near-shore deposits consist of slightly consolidated to cemented, poorly to well stratified pebble and cobble gravel with lenses of sand and silt to a thickness of 200 feet. The most extensive near-shore deposits occur in the northeast corner of the basin where the North Fork Pit River enters the valley. Other minor areas of these deposits occur but are not considered significant as water-bearing areas. These deposits have moderate permeability and may yield fair to moderate amounts of unconfined and confined water to wells.

The Pleistocene volcanic rocks consist of lava flows of layered, jointed basalt ranging in thickness from 50 to 250 feet. These basalt flows serve as recharge zones where exposed in the uplands surrounding the basin. Within the basin, where saturated, scoriaceous zones and joints in the basaltic flows can yield moderate amounts of water to wells. These flows occur interbedded with the upper member of the Alturas Formation in the valley areas.

The Plio-Pleistocene Alturas Formation consists of moderately consolidated, flat-lying beds of tuff, ashy sandstone, and diatomite, and is widespread both at the surface and at depth. The upper and lower sedimentary members of the formation are each about 400 feet thick, and are separated by a basalt member and the Warm Springs tuff. The sediments of the Alturas Formation are the principal water-yielding materials in the South Fork Pit River subbasin. These sediments have a moderate to high permeability and, where saturated, can yield large amounts of groundwater to wells. The formation contains both confined and unconfined groundwater.

Exposures of Warm Springs tuff in Sections 10 and 15, Township 42 North, Range 11 East, act as a partial barrier to the westward movement of groundwater from South Fork Pit River Valley to Warm Springs Valley (DWR 1963).

Water levels generally declined up to 10 feet in the northern part of the subbasin during the period from the early 1980s through the early 1990s and have recovered to former levels since 1999.

The groundwater storage capacity to a depth of 800 feet is estimated to be approximately 7.5 maf for the entire Alturas Groundwater Basin (which includes the South Fork Pit River Subbasin and the Warm Springs Valley Subbasin) (DWR 1963).

DWR estimates groundwater extraction for agricultural and municipal/industrial uses to be 13,000 and 260 acre-feet respectively. These estimates are based on surveys conducted by the DWR during 1997.

The groundwater regime between Warm Springs Valley and South Fork Pit River Valley is continuous through a north-to-northwest trending highland, west and south of Alturas, that forms two distinct valleys with separate surface drainage.

Exposures of Warm Springs tuff in Sections 10 and 15, Township 42 North, Range 11 East, act as a partial barrier to the westward movement of groundwater from South Fork Pit River Valley to Warm Springs Valley (DWR 1963).

The Alturas Groundwater Basin is utilized for irrigation. In 1979 DWR estimated pumpage of groundwater to be about 4,400 acre-feet (DWR 1986). The movement of groundwater through the Alturas Basin generally follows the topography.

The South Fork Pit River is the primary stream in the subbasin. It enters the subbasin from the south and continues north until is converges with the North Fork Pit River near Alturas in the northern portion of the subbasin. DWR (1986) states that the Pit River and its tributaries generally recharge the groundwater basin and therefore would not be a pathway for groundwater contaminant transport.

Major Sources of Recharge

Recharge to the subbasin is from precipitation, irrigation infiltration, and stream infiltration. Annual precipitation ranges from 13 to 19 inches. Deep percolation of applied water is estimated by DWR (2004) to be 9,600 acre-feet/year. The south and north forks of the Pit River influence groundwater in the subbasin.

Most recharge to the Alturas Groundwater Basin occurs in the upland areas of the western slope of the Warner Mountains (DWR 1986). The Pit River and other tributary streams recharge the groundwater in the subbasin as well.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. The South Fork Pit River subbasin is overlain with 31% agricultural land uses, 26% of which is rangeland. Table 4-34 provides details of the land uses within the subbasin.

Table 4-34. Land Use in the South Fork Pit River Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	2,446	2.14
Idle	632	0.55
Pasture	30,077	26.35
Rice	2,754	2.41
Semiagriculture and Incidental	480	0.42
Subtotal	36,389	31.88
Urban		
Commercial	172	0.15
Industrial	264	0.23
Urban Landscape	90	0.08
Urban Residential	2,671	2.34
Vacant	200	0.18
Subtotal	3,397	2.98
Native		
Riparian	2,542	2.23
Native Vegetation	69,372	60.78
Water	2,437	2.13
Subtotal	74,351	65.14
Total	**114,137**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. A key element of the ordinance requires an export permit for groundwater transfers out of the basin (DWR 2004). Alturas is the largest city in the subbasin. Public water agencies involved with the subbasin are the City of Alturas, California Pines Community Service District, and Hot Springs Valley Irrigation District. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Sodium bicarbonate and sodium-calcium bicarbonate type waters are the predominant water types in the subbasin. TDS ranges from 180 to 800 mg/L, averaging 357 mg/L. Water quality concerns in the Alturas Basin are high concentrations of TDS, nitrate, iron, and boron (DWR 1963).

In 1986, DWR published a study of the Alturas Basin (which includes the South Fork Pit River subbasin) groundwater quality. The study concluded that the general water quality of the Alturas Basin was good but there were some localized problems that were limiting the groundwater's beneficial use. The water quality issues were high concentrations of salts, sulfate, boron, and chloride. Most of the problem wells were wells that draw from the groundwater in the Alturas Formation and groundwater that migrates along faults. Table 4-35 displays the results of this study.

Table 4-35. Data from DWR Study of the Alturas Basin in 1986

Constituent Type	Constituent of Concern	Concentration ranges	Standards
Nutrients	Nitrate	0–38 mg/L, median is 4.2 mg/L (16 wells monitored)	10 (MCL)
Salt—as total dissolved solids.		100–1,600 mg/L, median is 260 mg/L	500 (SMCL)
	Adjusted sodium adsorption ratio (ASAR)	0–23.9 mg/L, 10 of 118 wells had values of 9 or greater	Ratio ≥ 9 can cause severe problems with sodium buildup in soils
Trace elements	Boron	0–4.6 mg/L, median is 0.03 mg/L	
	Chloride	0–271 mg/L, median is 8 mg/L	250 (SMCL)
	Sulfates	0–626 mg/L, median is 16 mg/L	250 (SMCL)
Hardness		2–506 mg/L (as $CaCO_3$), median is 76 mg/L	

Constituent Type	Constituent of Concern	Concentration ranges	Standards

Notes:
MCL = Maximum Contaminant Level set by EPA (2005).
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).

Warm Springs Valley Subbasin—Alturas Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Warm Springs Valley groundwater subbasin is located in Modoc County and is 68,000 acres (106 square miles) in size. It is bound on the east by a low mesa of the Plio-Pleistocene Alturas Formation (separating Warm Springs Valley from South Fork Pit River Valley); to the north by the Pleistocene basalt of Devils Garden; to the south by Plio-Pleistocene Warm Springs tuff and basalt and to the west by Pleistocene basalt (Gay 1968).

The groundwater regime between Warm Springs Valley and South Fork Pit River Valley is continuous through a north-to-northwest trending highland, west and south of Alturas, that forms two distinct valleys with separate surface drainage. From the confluence of the North and South Forks of the Pit River, just to the east at Alturas, the Pit River flows westerly through Warm Springs Valley.

The following description of the hydrogeology in the Warm Springs Valley subbasin is taken from DWR Bulletin 118 (DWR 2004).

The principal water-bearing formations are Holocene sedimentary deposits, Pleistocene lava flows, and Plio-Pleistocene Alturas Formation and basalts. The following summary of water-bearing formations is from DWR (1963).

The Holocene sedimentary deposits include alluvial fan deposits, intermediate alluvium, and basin deposits—each up to a thickness of 75 feet. Alluvial fan deposits consist of unconsolidated to poorly consolidated, crudely stratified silt, sand and gravel with lenses of clay. These deposits generally have high permeability and are capable of yielding large amounts of water to wells. This unit may include confined as well as unconfined water.

Intermediate alluvium consists of unconsolidated poorly sorted silt and sand with some lenses of gravel. These deposits have moderate permeability and yield moderate amounts of water to shallow wells.

Basin deposits consist of unconsolidated, interstratified clay, silt, and fine sand. These deposits have moderate to low permeability and yield small amounts of water to wells.

The Pleistocene volcanic rocks consist of lava flows of layered, jointed basalt ranging in thickness from 50 to 250 feet. These basalt flows serve as recharge zones where exposed in the uplands surrounding the basin. Within the basin, where saturated, scoriaceous zones and joints in the basaltic flows can yield moderate amounts of water to wells. These flows occur interbedded with the upper member of the Alturas Formation in the valley areas.

The Plio-Pleistocene Alturas Formation consists of moderately consolidated, flat-lying beds of tuff, ashy sandstone, and diatomite, and is widespread both at the surface and at depth. The upper and lower sedimentary members of the formation are each about 400 feet thick, and are separated by a basalt member and the Warm Springs tuff. The sediments of the formation are the principal water-yielding materials in the Warm Springs Valley Subbasin. These sediments have a moderate to high permeability and where saturated can yield large amounts of groundwater to wells. The formation contains both confined and unconfined groundwater.

The groundwater regime between Warm Springs Valley and South Fork Pit River Valley is continuous through a north-to-northwest trending highland, west and south of Alturas, that forms two distinct valleys with separate surface drainage.

Exposures of Warm Springs tuff in Sections 10 and 15, Township 42 North, Range 11 East, act as a partial barrier to the westward movement of groundwater from South Fork Pit River Valley to Warm Springs Valley (DWR 1963).

The Alturas Groundwater Basin is utilized for irrigation. In 1979 DWR estimated pumpage of groundwater to be about 4,400 acre-feet (DWR 1986). The movement of groundwater through the Alturas Basin generally follows the topography.

From the confluence of the North and South Forks of the Pit River, just to the east at Alturas, the Pit River flows westerly through Warm Springs Valley. DWR (1986) states that the Pit River and its tributaries generally recharge the groundwater basin and therefore would not be a pathway for groundwater contaminant transport.

Water levels declined approximately 20 feet in the western part of the subbasin during the period between 1985 and the early 1990s and have recovered to approximately 5 feet elevation as of 1999.

The groundwater storage capacity to a depth of 800 feet is estimated to be approximately 7.5 maf for the entire Alturas Groundwater Basin (which includes the South Fork Pit River Subbasin and the Warm Springs Valley Subbasin) (DWR 1963).

DWR estimates groundwater extraction for agricultural and municipal/industrial uses to be 3,000 and 270 acre-feet, respectively. These estimates are based on surveys conducted by the DWR during 1997.

Major Sources of Recharge

Recharge to the subbasin is from precipitation, irrigation infiltration, stream infiltration, and subsurface flow. Most recharge occurs in the upland areas of Devils Garden and Portuguese Ridge (DWR 1986). Upland recharge areas consist of permeable lava flows of Plio-Pleistocene and Pleistocene age. Precipitation falling on these areas infiltrates the lava flows and moves toward the valley floor (DWR 1963). The Pit River and other tributary streams recharge the groundwater in the subbasin as well. The average annual precipitation in the subbasin ranges from 13 to 19 inches increasing toward the west. Deep percolation of applied water is estimated by DWR (2004) to be 3,300 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1997. The Warm Springs Valley subbasin is overlain with 26% agricultural land uses, 21% of which is rangeland (pasture). Table 4-36 provides details of the land uses within the subbasin.

Table 4-36. Land Use in the Warm Springs Valley Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	1,731	2.55
Idle	1,873	2.75
Pasture	14,089	20.72
Semiagricultural and Incidental	172	0.25
Subtotal	17,865	26.27
Urban		
Urban—unclassified	316	0.47
Commercial	21	0.03
Industrial	186	0.27
Urban Landscape	4	0.01
Urban Residential	162	0.24
Vacant	89	0.13
Subtotal	777	1.14
Native		
Native Vegetation	47,207	69.41
Water	1,352	1.99
Riparian	807	1.19
Subtotal	49,366	72.59
Total	**68,008**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. Groundwater ordinances generally affect the volume of groundwater that can be pumped and/or exported from the subbasin. A key element of the Modoc County ordinance requires an export permit for groundwater transfers out of the basin (DWR 2004).

Public water agencies involved with the subbasin are the California Pines Community Service District, and Hot Springs Valley Irrigation District. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Sodium bicarbonate and sodium-calcium bicarbonate type waters are the predominant water types in the Alturas Groundwater Basin. The concentration of TDS ranges from 180 to 800 mg/L, averaging 357 mg/L (DWR 2004).

Kelly Hot Springs has water high in concentrations of TDS, boron, and fluoride. There is also high conductivity; adjusted sodium absorption ratio; and sulfate, iron, nitrate, calcium, manganese, and boron in localized areas of the subbasin. (DWR 2004)

In 1986, DWR published a study of the Alturas Basin (which includes the Warm Springs subbasin) groundwater quality. The study concluded that the general water quality of the Alturas Basin was good, but some localized problems were limiting the groundwater's beneficial use. The water quality issues were high concentrations of salts, sulfate, boron, and chloride. Most of the problem wells were wells that draw from the groundwater in the Alturas Formation and groundwater that migrates along faults. Table 4-37 displays the results of this study.

Table 4-37. Data from DWR Study of the Alturas Basin in 1986

Constituent Type	Constituent of Concern	Concentration ranges	Standards
Nutrients	Nitrate	0–38 mg/L, median is 4.2 mg/L (16 wells monitored)	10 (MCL)
Salt—as total dissolved solids.		100–1,600 mg/L, median is 260 mg/L	500 (SMCL)
	Adjusted sodium adsorption ratio (ASAR)	0–23.9, 10 of 118 wells had values of 9 or greater	Ratio ≥ 9 can cause severe problems with sodium buildup in soils
Trace elements	Boron	0–4.6 mg/L, median is 0.03 mg/L	
	Chloride	0–271 mg/L, median is 8 mg/L	250 (SMCL)
	Sulfates	0–626 mg/L, median is 16 mg/L	250 (SMCL)
Hardness		2–506 mg/L (as $CaCO_3$), median is 76 mg/L	

Notes:
MCL = Maximum Contaminant Level set by EPA (2005).
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).

American Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The American Valley Basin is 11 square miles in size and is located in Plumas County. The following information about the physiography and hydrogeology of the basin is taken from DWR Bulletin 118 (2004). The American Valley Groundwater Basin is bounded to the southwest and northeast by a northwest trending fault system. The basin is bounded to the northeast by Paleozoic metavolcanic rocks and is bounded on all other sides by Paleozoic marine sedimentary and meta-sedimentary rocks of the Sierra Nevada. Spanish Creek drains the valley and is tributary to the North Fork Feather River to the northwest.

Hydrogeologic information was not available for the Water-Bearing Formations and groundwater level Trends for the American Valley Basin. Storage capacity is estimated to be 50,000 acre-feet for a saturated depth interval of 10–210 feet.

Well yields for municipal/irrigation wells in the basin average 40 gal/min, based on 2 well completion reports. Total depths of domestic wells range from 20 to 561 feet, with an average of 127 feet, based on 286 well completion reports. Total depths of municipal/irrigation wells range from 44 to 250 feet, with an average of 125 feet, based on 15 well completion reports. According to a 1997 DWR survey of land use and sources of water, the estimated groundwater extraction for municipal and industrial uses in the American Valley Basin is estimated to be 1,400 acre-feet. Deep percolation of applied water is estimated to be 800 acre-feet. Groundwater generally discharges to Spanish Creek and groundwater wells (DWR 2004).

Major Sources of Recharge

The primary source of groundwater recharge is precipitation ranges from 43 to 49 inches per year, increasing to the southwest (DWR 2004).

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land use accounts for over 42% of the subbasin, urban land use accounts for about 20% of the subbasin, and native land accounts for about 37% of the subbasin. Table 4-38 provides details on the distribution of land use throughout the American Valley Basin.

Table 4-38. Land Use in the American Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	3	0.05
Pasture	2,857	42.02
Semiagricultural and Incidental	33	0.49

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	2,893	42.55
Urban		
Commercial	136	2.01
Industrial	235	3.45
Urban Residential	931	13.69
Vacant	63	0.93
Subtotal	1,365	20.08
Native		
Riparian	226	3.32
Native Vegetation	2,303	33.88
Water	12	0.17
Subtotal	2,541	37.37
Total	**6,799**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for the American Valley Groundwater Basin. Public water agencies in the basin include Quincy Community SD and East Quincy Services District. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Between 1994 and 2000, groundwater in the American Valley Basin was sampled for primary inorganics, radiologicals, nitrates, pesticides, VOCs and SVOCs, and secondary inorganics, as required under CDPH Title 22 program. VOCs/SVOCs were detected at concentrations above the MCL in 1 of 13 wells sampled, and secondary inorganics were detected above the MCL in 7 of 29 wells sampled. Primary inorganics, radiologicals, nitrates, and pesticides were not detected above the MCL in any of the wells sampled (DWR 2004).

Antelope Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of the Antelope Creek Groundwater Basin is 3 square miles (2,040 acres) and it is located in Colusa County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Antelope Creek Groundwater Basin is located east of Black Mountain in Antelope Valley. The basin consists of Quaternary alluvium and is bounded on all sides by Upper Cretaceous marine deposits. Several northeast trending faults may transect the valley. The basin is drained to the north by Antelope Creek.

Hydrologic information was not available from DWR for the water-bearing formations, groundwater level trends, and groundwater storage in the basin. Based on a 1993 DWR survey of land use and water sources, groundwater extraction for municipal/industrial use is estimated to be 2 acre-feet. Deep percolation of applied water is estimated to be 1 acre-foot.

Major Sources of Recharge

Annual precipitation is approximately 18 inches and is the primary source of recharge in the basin (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 3% of the basin, urban land use accounts for about 3% of the basin, and native land accounts for about 94% of the basin. Table 4-39 provides details on the distribution of land use throughout the Antelope Creek Basin.

Table 4-39. Land Use in the Antelope Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	97	4.77
Subtotal	97	4.77
Urban		
Urban Residential	30	1.48
Subtotal	30	1.48
Native		
Native Vegetation	1,912	93.69
Water	1	0.07
Subtotal	1,913	93.75
Total	**2,041**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Colusa County adopted a groundwater management ordinance for the Antelope Creek Basin in 1998. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramneto Valley Water Quality Coalition.

Water Quality

Water-quality information for this basin could not be found.

Ash Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Ash Valley Groundwater Basin is an alluvial filled valley located within a region of northwest trending faults. The basin is bounded to the east and west by Miocene basalt, to the north by Pliocene basalt, and to the north by Tertiary pyroclastic rocks and Pliocene basalt. The valley is drained to the northwest by Ash Creek. The area of the basin is 4,870 acres and is located in northeastern Lassen County.

DWR estimated the groundwater extraction for the Ash Valley Basin from a 1997 survey. The survey included land use and sources of water. Groundwater extraction for municipal and industrial uses was estimated to be 3 acre-feet annually. Deep percolation of applied water was estimated to be 560 acre-feet annually.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation and irrigation. Annual precipitation in the valley ranges from 17 to 21 inches, increasing to the north (DWR 2004). Deep percolation of applied water was estimated to be 560 acre-feet by DWR in 1997. The valley is drained to the northwest by Ash Creek.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 37% of the basin and native land accounts for about 63% of the basin. There is no urban land in the Ash Valley basin. Table 4-40 provides details of the land uses within the basin.

Table 4-40. Land Use in the Ash Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	2,250	37.40
Subtotal	2,250	37.40
Native		
Native Vegetation	3,750	62.40
Water	10	0.20
Subtotal	3,760	62.60
Total	**6,010**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lassen County enacted a groundwater ordinance in 1999 that requires a permit for groundwater exported from the county. There are no known groundwater management plans or basin adjudications. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Bear Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Bear Valley Groundwater Basin is an elongated north-south trending valley located adjacent to the Stony Creek Fault. The basin consists of Quaternary alluvium bounded by Mesozoic lower Cretaceous marine sedimentary rocks and the Knoxville Formation (Jennings 1960). The basin is located in Colusa County and is 9,110 acres (14 square miles) in size.

DWR (2004) estimated groundwater extraction and percolation of applied water based on a 1993 survey. Groundwater extraction for municipal and industrial uses is estimated to be 5 acre-feet. Deep percolation of applied water is estimated to be 200 acre-feet.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation, infiltration of irrigation water and stream infiltration. Annual precipitation ranges from 21 to 23 inches. Deep percolation of applied water is estimated by DWR (based on a 1993 survey) to be 12 acre-feet. The basin is drained to the south by Bear Creek. Other creeks in the basin are Mill Creek, Trout Creek, Rathbone Creek, Arrasatre Creek, Metcalf Creek, and Grout Creek.

Land Uses

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 6% of the basin and native land use accounts for about 94% of the basin. Table 4-41 provides details of the land uses within the Bear Valley basin.

Table 4-41. Land Use in the Bear Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	120	1.32
Pasture	380	4.17
Semiagricultural and Incidental	10	0.11
Subtotal	510	5.59
Native		
Native Vegetation	1,380	97.87
Barren and Wasteland	50	0.55
Subtotal	8,610	94.41
Total	**9,120**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Colusa County enacted a groundwater ordinance in 1998. This ordinance limits the amount of groundwater exported from the county. There are no cities or water agencies in the Bear Valley Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Berryessa Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Berryessa Valley Basin aquifer system is 2 square miles in size and is located in Napa County. The following description of the hydrogeology in the Berryessa Valley Basin is taken from DWR Bulletin 118 (2004). The Berryessa Valley Basin is located on the eastern shores of Lake Berryessa in a sparsely populated region of Napa County along the western flanks of Rocky Ridge in the Coast Ranges, approximately 14 miles northwest of the town of Winters. Two narrow swaths of shallow alluvium along the banks of Lake Berryessa, each about 2.5 miles in length, define the basin. This alluvium extends into the lower elevations of the Berryessa Valley, which was flooded by Lake Berryessa after the construction of Monticello Dam in 1957.

Putah Creek, which flows into Lake Berryessa, is the primary surface water source for the Berryessa Valley, other than the lake. Additionally, several intermittent streams flow into Berryessa Valley Basin from the east. The basin is located within the Upper Putah Creek watershed.

Water Bearing Formations include Alluvium, described as poorly sorted stream and basin deposits. Beneath the alluvium lies the basement rock of the Lower Cretaceous Great Valley Sequence, comprised of marine mudstone, sandstone, and conglomerate. This basement rock is generally considered to be non-water bearing, but it does provide water through fractures.

No information related to groundwater level trends was available for this basin.

Major Sources of Recharge

The Berryessa Valley Basin receives approximately 18 inches to 24 inches of precipitation annually (DWR 2004) and this is the major source s of groundwater recharge. There is also stream recharge.

Land Use

Most of the lands in the Napa County area are low intensity brushlands, rangelands, and lands used in years past for quicksilver and gold mining (Sacramento Valley Water Quality Coalition 2004). Wine grape production encompasses the majority of intensive agricultural acreage in the county, with olive production providing the balance. The majority of land in wine grape and olive production is probably irrigated. Drip irrigation is almost exclusively the mode of water delivery to these crops, although a small percentage of lands utilize overhead sprinklers for early spring frost protection in wine grapes. Dryland pastures and oat hay acreages exist in the county as well. None of these lands are irrigated.

Land use surveys were conducted within the basin by DWR in 1999. Agricultural land use accounts for less than 1% of the basin, and native land use accounts for about 99% of the basin. Table 4-42 provides details on the distribution of land use throughout the Berryessa Valley Basin.

Table 4-42. Land Use in the Berryessa Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Semiagricultural and Incidental	11	0.80
Subtotal	11	0.80
Native		
Native Vegetation	1,159	84.30
Water	205	14.90
Subtotal	1,159	99.20
Total	**1,170**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There is currently no groundwater management plan in effect for the Berryessa Valley Basin. No public or private water agencies exist within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Information for groundwater quality in the Berryessa Groundwater Basin is unavailable.

Big Valley (5-15) Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Big Valley Basin (5-15) is bordered by Plio-Pleistocene extrusive rocks of Mt. Konocti and Camelback Ridge on the east and southeast, the Jurassic-Cretaceous Franciscan Formation to the west and south, and Clear Lake to the north. The basin shares a boundary with the Scott Valley Basin to the northwest and may be hydrologically contiguous. The basin area is 38 square miles and it is located in Lake County.

The following description of the hydrogeology in the Big Valley Basin is taken from DWR Bulletin 118 (2004). For the purpose of this basin summary, the valley has been divided into five subbasins based on geologic conditions, groundwater boundaries, and topography. These areas are referred to as the Western Upland, the Adobe Creek-Manning Creek Subbasin, the Kelseyville Subbasin, the Central Upland and Upper Big Valley Subbasin, and the Cole Creek Upland.

The Western Upland is a one-half to one-mile wide topographic bench located along the western margin of the basin. The Adobe Creek - Manning Creek Subbasin is located east of the Western Upland, extends north to the Big Valley Fault, and is hydrologically connected to the Kelseyville Subbasin. The Kelseyville Subbasin is located north of the Big Valley Fault and extends north to Clear Lake. The Central Upland and Upper Big Valley Subbasin includes the eastern half of the basin south of the Big Valley Fault and is geologically similar to the Western Upland but is separated topographically by the Adobe Creek—Manning Creek Subbasin and separated structurally by the Adobe Creek Fault system. The Cole Creek Upland is located east of the Central Upland and Upper Big Valley system and is bounded to the north by the Mt. Konocti volcanics and to the south by Camel Back Ridge.

The Big Valley Basin is comprised of extensive Quaternary to late Tertiary alluvial deposits, including fan deposits, lakebed and flood plain deposits, and terrace uplands. The primary water-bearing formations in the basin are Quaternary alluvium, lake, and terrace deposits and Upper Pliocene to Lower Pleistocene volcanic ash deposits.

Surface distribution of younger alluvium is observed throughout the Adobe Creek—Manning Creek and Kelseyville aquifer systems. The younger alluvium generally extends to depths of 40–90 feet and consists of alternating strata of gravel, sand, silt, and clay. Alluvial fan deposits extend from the eastern boundary to the northeast-southwest trending Adobe Creek Fault Zone.

Quaternary terrace deposits are observed south of the east-west trending Wight Way Fault system and along the western margin of the valley within the Western Upland. The deposits consist of red-brown, poorly stratified, sand, clay, and moderately well rounded gravels. Permeability of the formation is generally low. The deposits range in thickness from 50 to 100 feet.

Plio-Pleistocene lake deposits underlie all terrace deposits and younger alluvium in most places. The deposit consists of blue clay with alternating strata of shale and limestone. Permeability of the formation is generally low; however, groundwater flow through sedimentary strata and volcanic deposits can be significant. Thickness of the formation ranges up to 500 feet.

An unconsolidated coarse ash deposit ranging in depth from 70 to 240 feet has been encountered in a number of wells. The volcanic ash is a thin bed of lithic tuff confined within older semi-consolidated sediments and occupies the Western Upland, Adobe Creek-Manning Creek, and most of the Central Upland and Upper Big Valley aquifer system situated south of the Big Valley Fault. The ash layer is offset by the northeast/southwest trending Adobe fault system. Groundwater contained within the deposit is confined with pressure heads ranging from 100 to 150 feet. Thickness of the deposit averages 2 feet.

Groundwater levels in the Big Valley Basin tend to fluctuate from 5 to 15 feet in normal and dry years. There is no consistent decreasing trend in the aquifer levels; however, there are identified locations where overdraft conditions have occurred during drought years (Lake County Flood Control and Water Conservation District 1999). DWR (2004) estimated the storage capacity (to a depth of 100 feet) to be 105,000 acre-feet. Useable storage is estimated to be 60,000 acre-feet. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 24,000 and 410 acre-feet respectively. Deep percolation from applied water is estimated to be 5,600 acre-feet (DWR 2004).

Major Sources of Recharge

According to DWR (2004), recharge in the northern portion of the Big Valley Basin is primarily infiltration from Kelsey Creek and by underflow from the Adobe Creek-Manning Creek Subbasin. Underflow occurs mainly from more permeable zones at depths of 25–45 feet and 70–90 feet. A limited amount of underflow probably enters the basin from the Central Upland system and from Mt. Konocti. Some recharge by infiltration of rain, applied water, and creek water occurs in areas other than the Kelsey Creek flood plain; however, direct surface recharge is inhibited by clayey soil and the near surface clay layer. Recharge within the Adobe Creek-Manning Creek Subbasin is from percolation from the channels of Highland and Adobe Creeks and from underflow from the Western Upland and Central Upland areas. Precipitation in the basin ranges from 22 to 35 inches annually, decreasing to the northeast.

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 43% of the basin, urban land use accounts for about 1% of the basin, and native land accounts for about 56% of the basin. Table 4-43 provides details on the distribution of land use throughout the Big Valley Basin.

Table 4-43. Land Use in the Big Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	7,501	8.15
Idle	4,648	5.05
Pasture	25,794	28.02
Rice	933	1.01

Land Use	Acreage of Land Use	Percent of Land Use
Semiagrcultural and Incidental	634	0.69
Truck, Nursery, and Berry Crops	45	0.05
Subtotal	39,555	42.96
Urban		
Urban—unclassified	302	0.33
Commercial	19	0.02
Industrial	266	0.29
Urban Landscape	28	0.03
Urban Residential	242	0.26
Vacant	16	0.02
Subtotal	873	0.95
Native		
Riparian	6,056	6.58
Native Vegetation	44,731	48.59
Water	853	0.93
Subtotal	51,640	56.09
Total	**92,067**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance and an AB 3030 groundwater management plan in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). The County of Lake is the only public water agency within the Big Valley Basin (DWR 2004).

In 1992, Lake County adopted the Lake County Aggregate Resource Management Plan (ARMP), which updates and replaces the Creek Management Plan of 1981. The purpose of these plans is to limit in-channel gravel mining activities that compromise groundwater storage capacity and groundwater recharge to the aquifer (Lake County Flood Control and Water Conservation District 1999).

Lake County adopted County Ordinance No. 1823 in 1989 that sets minimum standards for the construction of water wells and requires destruction of unused wells in a manner that adequately protects the source aquifer.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

The groundwater chemistry in the Big Valley Basin is predominantly magnesium bicarbonate. TDS ranges from 270 to 790 mg/L, averaging 535 mg/L. High levels of boron are present in groundwater along the eastern, southern, and northern perimeters of the valley, at concentrations that may be injurious to crops (DWR 1978, 2004). Elevated levels of iron and boron have been detected in groundwater adjacent to faults that underlie the aquifer and are believed to be the result of intrusion of geothermal waters (Lake County Flood Control and Water Conservation District 1999). Boron and iron levels tend to be higher in the fall when groundwater levels are lower.

Contaminated groundwater has not been documented in the aquifer (Lake County Flood Control and Water Conservation District 1999), however, analysis in 1993 showed some increases in nitrate levels in individual wells. The nitrate source or contamination trends were not identified due to an insufficient number of wells analyzed.

Secondary inorganics were detected at concentrations above the MCL in 6 of 8 public supply wells sampled by DWR (2004). There were no detections above the MCL in the public supply wells sampled for primary inorganics, radiologicals, nitrates, pesticides, or VOCs/SVOCs.

Big Valley Basin (5-4)

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Big Valley groundwater basin (5-4) is located in Modoc and Lassen Counties and encompasses 92,000 acres. It is a broad, flat plain extending about 13 miles north-to-south and 15 miles east-to-west consisting of a series of depressed fault blocks surrounded by tilted fault block ridges. The basin is bounded to the north and south by Pleistocene and Pliocene basalt and Tertiary pyroclastic rocks of the Turner Creek Formation, to the west by Tertiary rocks of the Big Valley Mountain volcanic series, and to the east by the Turner Creek Formation.

The following description of the hydrogeology in the Big Valley Basin is taken from DWR Bulletin 118 (DWR 2004). The primary water-bearing formations in Big Valley are Holocene sedimentary deposits, Pliocene and Pleistocene lava flows, and the Plio-Pleistocene Bieber Formation.

The Holocene sedimentary deposits include basin deposits, intermediate alluvium, and alluvial fans - each having a thickness of up to 150 feet. Basin deposits, located predominately in low-lying areas in the central part of the valley, consist of unconsolidated interbedded clay, silt, and organic muck, all having low permeability. These deposits are not considered a significant water-bearing formation. Intermediate alluvium, found along the perimeter of the valley, consists of unconsolidated silt and sand with some clay and gravel. These deposits are generally moderately permeable with gravel zones being highly permeable. Alluvial fans consist of unconsolidated poorly stratified silt, sand, and gravel with some clay lenses. Because the fans occur in only a few small areas, they are not considered a significant source of water. Locally they may yield moderate amounts of water to wells.

Pliocene volcanic rocks consist of jointed and fractured basalt flows occurring to the north and south of Big Valley. Deposits range in thickness to 1,000 feet. The lavas are moderately to highly permeable and serve as recharge areas in the uplands and contain unconfined and confined zones in the valley.

Pleistocene volcanic rocks consist of jointed and fractured basalt flows having moderate to high permeability. Deposits range from 50 to 150 feet thick. These flows serve as recharge areas and yield moderate to large amounts of confined and unconfined groundwater to wells in the southern part of the valley.

The Bieber Formation consists of lake deposited diatomite, clay, silt, sand, and gravel. These interbedded sediments are unconsolidated to semi-consolidated and are moderately permeable. The formation ranges in thickness from 1,000 to 2,000 feet and underlies all of Big Valley. The principal water-bearing zones consist of white pumiceous sand and black volcanic sand and yield large amounts of water to wells where there's sufficient thickness and continuity.

Water levels of the confined aquifer system declined 12–15 feet during the period between the mid-1980s and the early 1990s. Water levels through 1999 had recovered 10–12 feet.

Storage capacity for the Big Valley Groundwater Basin is estimated to be 3,750,000 acre-feet to a depth of 1,000 feet (DWR 1963). DWR (1963) notes that the quantity of useable water in storage is unknown. DWR estimates groundwater extraction for agricultural and municipal/industrial uses to be 29,000 and 300 acre-feet, respectively. This estimate is based on surveys conducted by the DWR during 1997.

Major Sources of Recharge

Recharge to the Basin is from precipitation, irrigation infiltration, and surface water infiltration. The average annual precipitation ranges from 13 to 17 inches. Deep percolation of applied water is estimated by DWR (2004) to be 7,900 acre-feet. The Pit River is the major river passing through Big Valley. Big Swamp and several other reservoirs lie in the Valley.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Big Valley Basin is overlain with 43% agricultural land use, 28% of which is rangeland (pasture). Urban land uses make up about 1% and native land comprise 56% of the Basin. Table 4-44 provides details of the land uses within the basin.

Table 4-44. Land Use in the Big Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	7,501	8.15
Idle	4,648	5.05
Pasture	25,794	28.02
Rice	933	1.01
Semiagricultural and Incidental	634	0.69
Truck, Nursery, and Berry Crops	45	0.05
Subtotal	39,555	42.96
Urban		
Urban—unclassified	302	0.33
Commercial	19	0.02
Industrial	266	0.29
Urban Landscape	28	0.03
Urban Residential	242	0.26
Vacant	16	0.02

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	873	0.95
Native		
Riparian	6,056	6.58
Native Vegetation	44,731	48.59
Water	853	0.93
Subtotal	51,640	56.09
Total	**92,067**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. A key element of the Modoc County ordinance requires an export permit for groundwater transferred out of the basin (DWR 2004). Public water agencies involved with the basin are the Lassen County WD No. 1 and Lassen-Modoc County Flood Control and Water Conservation District. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Sodium-magnesium bicarbonate and sodium bicarbonate type waters are present in the basin. The concentration of TDS ranges from 141 to 633 mg/L, averaging 260 mg/L. (DWR 2004)

Two hot springs and one well with sodium sulfate type water have been identified in the basin east of Bieber. There are high concentrations of nitrates, manganese, fluoride, iron, sulfate, conductivity, calcium, adjusted sodium absorption ratio, and TDS in localized areas of the basin. Some groundwater has high concentrations of ammonia and phosphorus. (DWR 2004)

Blanchard Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Blanchard Valley Groundwater Basin is 3 square miles (2,200 acres) in size and is located in Colusa County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004). The Blanchard Valley Groundwater Basin consists of two elongated north-south trending subbasins located in Antelope Valley. Both subbasins are bounded on all sides by Upper Cretaceous marine deposits.

Additional hydrologic information was not available from DWR for the water-bearing formations, groundwater level trends, and groundwater storage in the basin. Based on a 1993 DWR survey of land use and sources of water, groundwater extraction for municipal/industrial use in the Blanchard Valley Basin is estimated to be 2 acre-feet/year. Deep percolation of applied water is estimated to be 1 acre-foot/year.

Major Sources of Recharge

Annual precipitation is approximately 21 to 23 inches and is the primary source of groundwater recharge.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1998. Agricultural land use accounts for about 10% of the subbasin and native land accounts for about 90% of the subbasin. Table 4-45 provides details on the distribution of land use throughout the Blanchard Valley Basin.

Table 4-45. Land Use in the Blanchard Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	231	10.40
Subtotal	231	10.40
Native		
Native Vegetation	1,983	89.22
Water	8	0.38
Subtotal	1,992	89.60
Total	**2,223**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Colusa County adopted a groundwater management ordinance in 1998. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Information for groundwater quality for this basin could not be located.

Burney Creek Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Burney Creek Valley Groundwater Basin is bounded to the west by north trending faults. The basin is bounded on all sides by Pleistocene basalt. Burney Creek drains the valley to the north. The area of the basin is 2,350 acres and is located in eastern Shasta County. The water-bearing formation in the basin consists of Quaternary lake deposits. Groundwater extraction for municipal and industrial uses is estimated by DWR (2004) to be 790 acre-feet.

The 1984 DWR study of the Eastern Upland area of Shasta County showed potential groundwater supply limitations in the area north of State Highway 299 in the Eastern Upland planning area.

Major Sources of Recharge

Recharge to the Burney Creek Valley aquifer is mostly by infiltration precipitation into the alluvium. Annual precipitation is about 27 inches. DWR (2004) estimated recharge by deep percolation of applied water at 490 acre-feet.

Land Use

Land use surveys were conducted within the basin by DWR in 1999. The foothills situated in the Eastern Upland region of Shasta County, which contains Burney Creek Valley basin contain a high percent of rangelands. Of the 60% land uses that are agricultural in this basin, 41% is pasture. Fifteen percent of the basin is urban and 25% is native. Table 4-46 provides details of the land uses within the basin.

Table 4-46. Land Use in the Burney Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Idle	430	18.30
Pasture	970	41.28
Semiagricultural and Incidental	10	0.43
Subtotal	1,410	60.00
Urban		
Urban—unclassified	320	13.62
Urban Residential	30	1.28
Vacant	10	0.43
Subtotal	360	15.32
Native		
Riparian	10	0.43
Native Vegetation	570	24.26
Subtotal	580	24.68

Land Use	Acreage of Land Use	Percent of Land Use
Total	**2,350**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. Along with Shasta County, the Burney Water District is the only water agency that manages the water in the Burney Creek Valley basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

There is insufficient water quality data available to determine the effects of irrigated agriculture.

Burns Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of Burns Valley Basin is 4 square miles and it is located in Lake County. The following description of the physiography and hydrogeology in the Burns Valley Basin is taken from DWR Bulletin 118 (2004).

Burns Valley Basin is located along the southeastern edge of Clear Lake and consists of low-lying alluvial plains and upland terrace deposits. The basin is bounded by basalt flows to the northwest and the Plio-Pleistocene Cache Formation on all other sides with the exception of Olivine basalt to the southeast. The west side of the basin opens to Clear Lake. The Cache Formation underlies the majority of the basin. Assuming that there is hydraulic continuity between the alluvium and the Cache Formation, groundwater is in hydraulic continuity in all directions beyond the alluvial plain with the exception being to the northwest. Basement rock consists of the Jurassic-Cretaceous Franciscan Formation and volcanics.

Quaternary alluvium, upland terrace deposits, and the Plio-Pleistocene Cache Formation are the primary water-bearing deposits in the valley. Lowlands in the valley are composed of stream channel gravel and adjacent floodplain deposits of several unnamed creeks. The Quaternary alluvium of the lowland deposits is composed of silt, sand, and gravel. Its maximum thickness at the lower end of the valley is approximately 50 feet. Groundwater is essentially unconfined and yields water for domestic use.

On either side of the alluvial plain are remnants of a least two levels of terrace deposits. The deposits are approximately 15 feet above the valley floor and slope up the valley and merge with the Cache terrain. The deposits consist almost entirely of clastic debris from the Cache formation.

Plio-Pleistocene Cache formation deposits underlie all alluvial and terrace deposits. The formation is largely made up of lake deposits with the potential for included stream deposits. The formation consists of fine sands, silts, and thin interbeds of marl and limestone to a thickness of 200 feet. Near the top of the formation, water-laid tuffs and tuffaceous sands become dominant with intercalated clay, marl, limestone, and diatomite. The formation has low permeability and yields water to wells at rates up to a few hundred gallons per minute.

Storage capacity is estimated to be 4,000 acre-feet based on an area of 1,000 acres, a saturated thickness of 50 feet, and a specific yield of 8%. A 1960 estimate of useable storage capacity is 1,400 acre-feet. Estimates of groundwater extraction for the Burns Valley Basin are based on a survey conducted by the DWR in 1995 (DWR 2004). The survey included land use and sources of water. An estimate of groundwater extraction for agricultural use is 900 acre-feet. Deep percolation from applied water is estimated to be 210 acre-feet.

Major Sources of Recharge

Almost all of the groundwater of Burns Valley is derived from rain that falls within a 12.5 square mile drainage area. Annual precipitation in the basin is approximately 27 inches (DWR 2004).

Land Uses

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 20% of the basin, urban land use accounts for about 17% of the basin, and native land accounts for about 63% of the basin. Table 4-47 provides details on the distribution of land use throughout the Burns Valley Basin.

Table 4-47. Land Use in the Burns Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	382	13.30
Idle	31	1.08
Vineyards	169	5.88
Subtotal	582	20.26
Urban		
Commercial	48	1.68
Industrial	28	0.96
Urban Landscape	6	0.20
Urban Residential	401	13.96
Vacant	7	0.24
Subtotal	490	17.05
Native		
Native Vegetation	1,772	61.64
Water	30	1.05
Subtotal	1,802	62.69

Land Use	Acreage of Land Use	Percent of Land Use
Total	**2,875**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Groundwater management for the Burns Valley Basin is under Lake County. Highland Mutual Water Company is the sole (private) water agency in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

DWR monitors 5 wells biennially for various water quality parameters. Groundwater in the basin consists of magnesium-calcium type waters. TDS ranges from 280 to 455 mg/L, averaging 335 mg/L. Groundwater in the basin has high sodium and iron concentrations. Locally high manganese, magnesium, calcium, and phosphorus also occur. High boron concentrations may be an issue for groundwater for agricultural irrigation (DWR 2004, 1975).

Butte Creek Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Butte Creek Valley groundwater basin is located in Lassen County and is 3,230 acres (5 square miles) in size. The basin is located to the west of Crater Lake Mountain and to the northwest of Project Peak in southwest Lassen County. The basin is an alluvium filled valley bounded on all sides by Pleistocene basalt. Highway 44 (Feather Lake Highway) traverses the valley.

Major Sources of Recharge

Recharge to the basin is from precipitation, intermittent lake and stream infiltration and surface runoff. The average annual precipitation in the basin ranges from 17 to 19 inches.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Native vegetation comprises 99% of the basin, with industrial urban use occupying the remaining 1% of land. Table 4-48 provides details of the land uses within the basin.

Table 4-48. Land Use in the Butte Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Industrial	30	0.93
Subtotal	30	0.93
Native		
Native Vegetation	3,200	99.07
Subtotal	3,200	99.07
Total	**3,230**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications. There are no water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Cayton Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cayton Valley groundwater basin is located in Shasta County and is 1,300 acres (2 square miles) in size. It is a northeast trending basin located west of Fall River Valley and north of Lake Britton. The basin is bounded to the east by several northwest trending faults and Pliocene andesitic rocks of Soldier and Fort Mountains. The basin is bounded to the north and west by Miocene basalt and to the south by Quaternary pyroclastic rocks.

DWR estimates groundwater extraction for municipal and industrial uses to be 1 acre-foot per year. These estimates are based on surveys conducted by the DWR during 1995.

Major Sources of Recharge

Recharge to the basin is from precipitation, irrigation infiltration, and stream infiltration. The average annual precipitation in the basin ranges from 35 to 41 inches, increasing toward the northwest. Deep percolation of applied water is estimated by DWR (2004) to be 210 acre-feet. Cayton Creek, which traverses the basin, is a tributary to the Pit River.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. The Cayton basin is overlain with 73% agricultural land uses, 69% of which is rangeland (pasture). Table 4-49 provides details of the land uses within the basin.

Table 4-49. Land Use in the Cayton Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	907	69.40
Semiagricultural and Incidental	8	0.58
Idle	45	3.45
Subtotal	959	73.42
Native		
Native Vegetation	347	26.52
Water	1	0.06
Subtotal	347	26.58
Total	**1,307**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. There are no water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Chrome Town Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Chrome Town Area Groundwater Basin is a north-south trending basin located near the eastern margin of the Coast Range consisting of Quaternary stream terrace deposits. The basin is bounded to the east by the Jurassic Knoxville Formation and lower Cretaceous marine sedimentary deposits. The basin is bounded on all other sides by the Jurassic Knoxville Formation (Jennings 1969). The basin is located in Glenn County and is 1,410 acres (2 square miles) in size.

DWR (2004) estimated groundwater extraction and percolation of applied water based on a 1993 survey. Groundwater extraction for municipal and industrial uses is estimated to be 5 acre-feet. Deep percolation of applied water is estimated to be 200 acre-feet.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation, infiltration of irrigation water and stream infiltration.

Annual precipitation is approximately 21 inches. Deep percolation of applied water is estimated to be 3 acre-feet. Chrome Creek drains the area in the north while Chrome creek, a tributary to Stony Creek, drains the area in the south.

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 2% of the basin and native land use accounts for about 98% of the basin. Table 4-50 provides details of the land uses within the Chrome Town Area basin.

Table 4-50. Land Use in the Chrome Town Area Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Semiagricultural and Incidental	30	2.13
Subtotal	30	2.13
Native		
Native Vegetation	1,380	97.87
Subtotal	1,380	97.87
Total	**1,410**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County enacted a groundwater ordinance in 1990 and revised it in 2000. The key issues in the ordinance are the establishment of a Water Advisory Committee and Technical Advisory Committee, the establishment of basin management objectives, the establishment of a monitoring network and a requirement of permits for the exportation of groundwater outside the County. There are no cities and no water agencies in the Chrome Town Area Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Clear Lake Cache Formation Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Clear Lake Cache Formation Groundwater Basin is 47 square miles in size and is located in Lake County. The following description of the hydrogeology for the basin is taken from DWR Bulletin 118 (2004).

The Clear Lake Cache Formation Groundwater Basin is located east of Clear Lake and shares a basin boundary with the Burns Valley Groundwater Basin to the southwest. The basin is bounded to the south by lower Cretaceous marine and Knoxville Formation deposits and Mesozoic ultra-basic intrusive rocks. The basin is bounded on the east by lower Cretaceous marine deposits and to the north and west by rocks of the Franciscan Formation. The basin is drained by the North Fork Cache Creek and by Cache Creek. Faulting is observed along portions of the western and southern boundaries.

The primary water-bearing formation is the Cache Formation. The Cache Formation is largely made up of lake deposits. The formation consists of tuffaceous and diatomaceous sands and silts, limestone, gravel, and intercalated volcanic rocks. In some areas the general lithology includes up to 400 feet of blue clay and shale with alternating strata of shale and limestone below 400 feet. The permeability of the formation is generally low.

According to DWR (2004), there is no hydrogeologic information available concerning groundwater level trends and storage.

Well completion reports in the basin showed a yield range for 12 municipal/irrigation wells from 11 to 245 gal/min, with an average of 52 gal/min. The average total depth of domestic wells (113 wells reported) is 103 feet, with a range from 23 to 450 feet. The average total depth of municipal/irrigation wells (23 wells reported) is 162 feet, with a range from 58 to 380 feet (DWR 2004).

Based on a 1995 DWR survey of land use and sources of water, the estimate of groundwater extraction for municipal/industrial use is 55 acre-feet. Deep percolation from applied water is estimated to be 61 acre-feet.

Major Sources of Recharge

Precipitation is the primary source of recharge and ranges from 25 to 29 inches.

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for less than 1% of the basin, urban land use accounts for about 6% of the basin, and native land use accounts for about 93% of the basin. Table 4-51 provides details on the distribution of land use throughout the Clear Lake Cache Formation Basin.

Table 4-51. Land Use in the Clear Lake Cache Formation Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	5	0.02
Idle	16	0.05
Semiagricultural and Incidental	8	0.03
Vineyards	154	0.52
Subtotal	182	0.61
Urban		
Commercial	71	0.24
Industrial	85	0.28
Urban Residential	1,715	5.77
Vacant	39	0.13
Subtotal	1,910	6.42
Native		
Native Vegetation	27,534	92.58
Water	114	0.38
Subtotal	27,648	92.96
Total	**29,740**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). County of Lake is the sole public water agency in the basin. There are no private agencies reported. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater sampling performed under the requirements of the CDPH Title 22 program from 1994 through 2000 tested for primary and secondary inorganics, radiologicals, nitrates, pesticides, VOCs, and SVOCs. All three of the wells sampled for secondary inorganics showed concentrations above the MCLs for those constituents. Concentrations above the MCL for the other constituents were not detected (DWR 2004).

Clover Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Clover Valley Groundwater Basin is an irregular shaped basin that includes McReynolds Valley, Squaw Valley, Clover Valley, and Wakeynolds Valley. The valleys consist of deposits of alluvium and lake sediments. The basin is bounded by Miocene volcanic rocks on the north, east, and south and by recent volcanic and Mesozoic granitic rocks to the west. Dixie Creek and Red Clover Creek drain the southern two-thirds of the basin to the west and Squaw Queen Creek drains the northern third of the basin to the northeast. The basin is 16,780 acres (26 square miles) in size and is located in Plumas County. Dixie Creek and Red Clover Creek drain the southern two-thirds of the basin to the west and Squaw Queen Creek drains the northern third of the basin to the northeast.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation. Annual precipitation ranges from 19 to 27 inches, increasing to the south.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Clover Valley contains only native land (Table 4-52).

Table 4-52. Land Use in the Clover Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	10,440	62.20
Riparian	6,340	37.80
Total	16,780	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no groundwater management plans or ordinances, basin adjudications, water agencies, or urban areas within the Clover Valley Basin.This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Collayomi Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Collayomi Valley Basin aquifer system is 10 square miles in size and is located in Lake County. The following description of the hydrogeology in the Collayomi Valley Basin is taken from DWR Bulletin 118 (2004).

The Collayomi Basin includes both Collayomi Valley and Long Valley in the headwater area of Putah Creek. The two northwest-southeast trending valleys are considered a single groundwater basin due to their hydrologic continuity. The basin is bounded to the south by Jurassic-Cretaceous Franciscan, Knoxville, and volcanic rocks; to the west by undifferentiated Cretaceous rocks and Jurassic volcanic rock; to the north and northeast by Plio-Pleistocene Olivine basalt; and to the east by Jurassic volcanics. The basin is underlain by non-water-bearing sedimentary rocks of Jurassic-Cretaceous Franciscan and Knoxville formations that are capped locally by volcanic rocks. The basin boundary coincides with the edge of the valley floor except where water-bearing landslide debris and Quaternary basalt extend from beneath the valley floor into the uplands.

Nearly all groundwater throughout the Collayomi Basin occurs in Quaternary alluvium deposited as alluvial fans of shallow grade and in the gravel channels of Putah Creek, St. Helena Creek, and their tributaries. Groundwater occurs in a series of confined, semi-confined, and unconfined layers and lenses of permeable or semi-impermeable materials that are partially merged and interconnected. There is no evidence of any well-defined aquifer of any great areal extent within the basin. Pleistocene volcanics may also be a source of groundwater in the basin; however, no information is available on storage capacities and well yields within these units.

Quaternary alluvium in Collayomi Valley and Long Valley consists primarily of fine-grained deposits of clay and silt. However, alluvium in Collayomi Valley contains some coarse gravel channels and is more conducive to groundwater development in the basin. Along the channels of Putah and St. Helena Creeks, visible shallow deposits consist of fine sand to coarse cobbles and boulders with clean coarse gravel being dominant. In Long Valley, wells within the alluvial plain consist primarily of fine-grain material with low yields. A well log for Long Valley indicates that the alluvial fill is almost entirely clay from a depth of 64 to 230 feet. The maximum depths of alluvial fill in Collayomi and Long Valleys are approximately 350 feet and 475 feet respectively.

Storage capacity in the basin is estimated to be approximately 29,000 acre-feet. This is based on the assumptions that alluvium is 100 feet deep over an area of 4,000 acres with specific yield values of 6.5 and 4.5% for Collayomi and Long valleys respectively. Useable storage capacity is estimated at 7,000 acre-feet (DWR 2004). Maximum well yield is 1,200 gal/min, with an average yield of 500 gal/min (DWR 1975).

Major Sources of Recharge

The major source of recharge to the Collayomi Basin is from percolation of streamflow in Putah Creek, Dry Creek, and St. Helena Creek, although some recharge is derived from irrigation return flows and infiltration of rainfall. Annual precipitation in the basin ranges from 41 to 47 inches, decreasing to the northeast. Only minor quantities of surface streamflow are available for recharge in the Long Valley portion of the basinwhich may be impeded by hardpan conditions near the ground surface (DWR 2004).

Land Use

Estimates of groundwater extraction are based on a survey conducted by the DWR in 1995. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 1,000 and 94 acre-feet respectively. Deep percolation from applied water is estimated to be 250 acre-feet (DWR 2004).

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 13% of the basin, urban land use accounts for about 9% of the basin, and native land accounts for about 78% of the basin. Table 4-53 provides details on the distribution of land use throughout the Collayomi Valley Basin.

Table 4-53. Land Use in the Collayomi Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	95	1.47
Grain and Hay	190	2.92
Idle	118	1.82
Pasture	88	1.35
Semiagricultural and Incidental	74	1.14
Vineyards	292	4.49
Subtotal	857	13.18
Urban		
Urban—unclassified	54	0.83
Commercial	26	0.40
Industrial	93	1.43
Urban Landscape	14	0.21
Urban Residential	395	6.07
Vacant	10	0.16
Subtotal	592	9.10
Native		
Native Vegetation	5,032	77.39
Water	21	0.33
Subtotal	5,053	77.72
Total	**6,502**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County has adopted a groundwater management ordinance in 1999 for the Collayomi Valley Basin. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). The public water agencies within the basin include Hidden Valley Lake CSD and Middletown County Water District. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater in the basin is characterized as magnesium bicarbonate type waters. TDS range from 150 to 255 mg/L, averaging 202 mg/L. Groundwater sampling shows locally high iron and manganese. Locally high boron may be an issue for agricultural uses (DWR 2004).

Coyote Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Coyote Valley Basin is 10 square miles in size and is located in Lake County. The following description of the physiography and hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

Coyote Valley is a northwest-southeast trending valley located within the southeastern portion of Lake County along Putah Creek about 4 miles northeast of Middletown. The valley is approximately 5 miles long and a maximum of 2.5 miles in width. The alluvial plain of the valley is bounded by sediments of the Jurassic-Cretaceous Franciscan-Knoxville groups and undifferentiated Cretaceous rocks on the west and northwest. The south and southeastern part of the valley is nearly isolated by low hills of basalt of Upper Jurassic age. The Plio-Pleistocene Cache Formation outcrops along the northern edge of the valley and Plio-Pleistocene basalt outcrops are observed at the northeastern valley edge. The aquifer system of Coyote Valley Basin is primarily comprised of Quaternary Holocene alluvial deposits and, to a much lesser extent, Plio-Pleistocene Cache Formation deposits.

Holocene alluvium within the valley overlies the Cache Formation and is the primary water-bearing unit in the basin. The alluvium is made up of floodplain and channel deposits of Putah Creek and gently sloping alluvial fan deposits in the southwestern lobe of the valley and at the valley margins. The deposits consist of poorly stratified sand, gravel, and fine-grained material. The most productive strata are gravels that occur in sheets and stringers between beds of silty and sandy clay. The alluvial fill may range in thickness from 100 to 300 feet.

Volcanic rocks and underlying tuffaceous deposits (Upper Cache Formation) exist along the north edge and in the southeastern part of the valley and may be water bearing. The tuffaceous deposits are poorly consolidated and apparently lie at considerable depth beneath the hills to the northeast, where they are overlain by, and possibly interbedded with, basaltic flows. The lithology of the sediments associated with lava flows along the north edge of Coyote Valley is like that of the Upper Cache near Clear Lake, except for the composition of the cobble gravels, which are composed largely of rounded cobbles of white rhyolite. The Cache Formation outcrops on the northeast edge of Coyote Valley and probably underlies much of the Holocene alluvium. It is composed of gravel, silt, and sand, and near the top of the section, water–laid tuffs and tuffaceous sands become dominant. The permeability in the Cache formation is variable, but generally low. Most of the strata are too high in clay or silt for water movement to be great. Groundwater flow through a few coarse sedimentary strata and volcanic deposits may be appreciable.

Storage capacity of the basin is estimated to be 27,000 acre-feet. This estimate is based on the areal extent of alluvium within the basin (approximately 3,000 acres) for a saturated depth interval of 10 to 100 feet, having a specific yield of 10%. In 1960 DWR estimated the storage capacity to be 29,000 acre-feet with a useable storage capacity of 7,000 acre-feet.

Estimates of groundwater extraction for agricultural and municipal/industrial uses are 1,400 and 290 acre-feet respectively, based on a 1995 groundwater extraction survey conducted by the DWR. Deep percolation from applied water is estimated to be 1,100 acre-feet.

Major Sources of Recharge

The major source of groundwater recharge is from Putah Creek. Lesser amounts of recharge occur from precipitation upon the alluvial plain and from side-stream runoff. Annual precipitation in the valley ranges from 37 to 41 inches, increasing to the north (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 34% of the basin, urban land use accounts for about 14% of the basin, and native land accounts for about 52% of the basin. Table 4-54 provides details on the distribution of land use throughout the Coyote Valley Basin.

Table 4-54. Land Use in the Coyote Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	54	0.82
Grain and Hay	192	2.93
Idle	349	5.35
Pasture	1,039	15.90
Semiagricultural and Incidental	46	0.70
Vineyards	524	8.02
Subtotal	2,203	33.72
Urban		
Urban—unclassified	20	0.31
Commercial	48	0.74
Industrial	45	0.69
Urban Landscape	117	1.79
Urban Residential	691	10.58
Vacant	8	0.12

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	929	14.22
Native		
Native Vegetation	3,181	48.69
Water	220	3.36
Subtotal	3,401	52.06
Total	**6,533**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance for the basin in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). No private or public water agencies are listed. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater in the basin consists of magnesium bicarbonate type waters. TDS ranges from 175 to 390 mg/L, averaging 288 mg/L. Water quality sampling shows locally high magnesium (DWR 2004).

Dixie Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Dixie Valley Groundwater Basin is an elongated east/west trending alluvial basin located south of Bald Mountain and west of Madeline Plains in western Lassen County. The basin is bounded to the south by Pleistocene basalt and on all other sides by Pliocene basalt (Lydon 1960). Indian Creek flows into the valley from the east. The valley is drained by Horse Creek, which flows northwest to the Pit River. The basin is 4,870 acres (8 square miles) in size and is located in northeastern Lassen County.

There is no information about the hydrogeology of Dixie basin available.

DWR estimated the groundwater extraction for the Dixie Valley Basin from a 1997 survey. The survey included land use and sources of water. Groundwater extraction for municipal and industrial uses was estimated to be 2 acre-feet annually. Deep percolation of applied water was estimated to be 420 acre-feet annually.

Major Sources of Recharge

Recharge to the basin is from precipitation, irrigation infiltration, and stream infiltration.

Annual precipitation in the valley ranges from 17 to 19 inches, increasing to the north. Deep percolation of applied water was estimated to be 420 acre-feet by DWR in 1997. Indian Creek flows into the valley from the east. The valley is drained by Horse Creek, which flows northwest to the Pit River.

Land Uses

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 54% of the basin and native land use accounts for about 46% of the basin. There is no urban land in the Dixie Valley basin. Table 4-55 provides details of the land uses within the basin.

Table 4-55. Land Use in the Dixie Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	2,470	50.70
Semiagricultural and Incidental	10	0.20
Idle	140	2.90
Subtotal	2,620	53.80
Native		
Native Vegetation	2,180	44.80
Water	70	1.40
Subtotal	2,250	46.20
Total	**4,870**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lassen County enacted a groundwater ordinance in 1999 that requires a permit for groundwater exported from the county. There are no known groundwater management plans or basin adjudications. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

No water quality data are available for this basin.

Dry Burney Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Dry Burney Creek Valley Groundwater Basin is bounded to the northwest, west, and south by Pliocene andesite of Don Hurt Mountain, Stacher Butte, and Jacks Backbone. The basin is bounded to the east by Pleistocene basalt of Whittington Butte and Horse Heaven Buttes (Lydon 1960). The basin is 3,070 acres (5 square miles) in size and is located in eastern Shasta County.

The water-bearing formation in the basin is the Quaternary alluvium.

Major Sources of Recharge

Recharge to the aquifer is mostly by infiltration precipitation into the alluvium. Annual precipitation ranges from 49 to 55 inches, increasing to the southeast.

Land Uses

Land use surveys were conducted within the basin by DWR in 1999. Dry Burney Creek Valley basin is 100% native vegetation (Table 4-56).

Table 4-56. Land Use in the Dry Burney Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	3,080	100.00
Total	3,080	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. No water agencies are involved with the management of Dry Burney Creek Valley basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

No water quality data are available for this basin.

Egg Lake Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Egg Lake Valley Basin is 6 square miles (4,100 acres) in size and is located in Modoc County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004). The Egg Lake Valley Basin is bounded to the south by Tertiary volcanics of Egg Lake Butte, to the east by recent basalt, and on all other sides by Miocene basalt. The basin consists of Quaternary lake deposits.

The single municipal/irrigation well in the basin is reported to have a yield of 20 gal/min and a total depth of 440 feet. A domestic well in the basin is reported to have a total depth of 300 feet. No information is available on the yield of the domestic well. (DWR 2004.)

Major Sources of Recharge

Annual precipitation is the major source of recharge and ranges from 19 to 21 inches.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. The entire basin consists of native vegetation and surface water features (rivers, lakes, etc.). Table 4-57 provides details on the distribution of land use throughout the Egg Lake Valley Basin.

Table 4-57. Land Use in the Egg Lake Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	1,617	39.41
Water	2,485	60.59
Total	4,102	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the Modoc County ordinance is the requirement of an export permit for groundwater transferred out of the basin (DWR 2004). There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

As required under the CDPH Title 22 program, wells within the basin were sampled for the presence of primary and secondary inorganics, nitrates, pesticides, VOCs, and SVOCs. None of the wells sampled from 1994 through 2000 had detections above the respective MCLs (DWR 2004).

Elk Creek Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Elk Creek Groundwater Basin is located in east-central Glenn County and is 1,450 acres (2 square miles) in size. Stony Creek borders the basin on the southeast while Elk Creek flows down the center of the Valley. Stony Creek and Elk Creek converge in the basin. Elk Creek, Briscoe Creek, and Stony Creek drain the Valley. There is no hydrogeologic information available for Elk Creek Valley basin.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation, infiltration of irrigation water and stream infiltration.

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 6% of the basin, urban land use makes up about 6% of the basin and native land accounts for about 88% of the basin area. Table 4-58 provides details of the land uses within the Elk Creek Valley basin.

Table 4-58. Land Use in the Elk Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Citrus and Subtropical	60	4.14
Field Crops	30	2.07
Subtotal	90	6.21
Urban		
Urban	60	4.14
Commercial	10	0.69
Urban Landscape	10	0.69
Subtotal	80	5.52
Native		
Riparian	20	1.38
Native Vegetation	1,200	82.76
Water	60	4.14

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	1,280	88.28
Total	**1,450**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County enacted a groundwater ordinance in 1990 and revised it in 2000. The key issues in the ordinance are the establishment of a Water Advisory Committee and Technical Advisory Committee, the establishment of basin management objectives, the establishment of a monitoring network and a requirement of permits for the exportation of groundwater outside the County. There are no cities and no water agencies in the Elk Creek Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Fall River Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Fall River Valley groundwater basin is 54, 800 acres in size and is located in Lassen and Shasta Counties at 3,300 feet elevation. It is bounded on the east by Tertiary basalt of the Big Valley Mountains, and on the west by Pleistocene basalt and Pliocene andesite of Soldier and Saddle Mountains. Less distinct boundaries are to the north and south as low relief volcanic plateau areas of basalt. Fall River is the primary stream draining the northern and central-valley areas, and the Pit River is the primary stream in the easterly and southerly portion of the basin. These rivers converge at the southwestern corner of the valley near Fall River Mills and flow westward out of the valley.

The following description of the hydrogeology in the Fall River Valley basin is taken from DWR Bulletin 118 (DWR 2004).

The primary water-bearing formations are Holocene sedimentary deposits, Holocene lava flows, Pleistocene lake and near-shore deposits, and Pleistocene to Pliocene volcanic rocks.

Holocene sedimentary deposits include intermediate alluvium and alluvial fans. The intermediate alluvium consists of unconsolidated silt, sand, and gravel up to 100 feet thick. These deposits occur along stream channels and on the floodplain. The permeability of these materials is moderate to high. However, with the exception of some areas along Bear Creek and the Pit River, the alluvial deposits are too thin to be of importance for groundwater development.

The alluvial fans consist of unconsolidated, poorly stratified silt, sand, and gravel to a thickness of 200 feet. These deposits are limited to the eastern margin of the valley and are primarily recharge areas but may yield moderate quantities of groundwater in places. These deposits are moderately permeable and contain confined and unconfined zones.

The Holocene volcanic rocks originate from the Medicine Lake Highlands and consist of highly jointed, vesicular basalt flows, scoria, cinder cones, and associated lenses of cinders ranging in thickness from 30 to 500 feet. These volcanic rocks are highly permeable. At the north end of the valley, where these deposits mantle the uplands, they serve as a major recharge area and feed numerous streams and springs.

Pleistocene near-shore deposits consist of partly consolidated clay, silt, and sand up to 300 feet thick. These deposits are moderately permeable and yield fair quantities of groundwater to wells.

Pleistocene volcanic rocks consist of partly consolidated, bedded cinders and highly jointed basalt flows ranging from 50 to 750 feet in thickness. The cinder beds are highly permeable but are of limited extent and are not significant valley wide. Overall, the basalt flows are moderately to highly permeable and can yield large amounts of confined water where interbedded with lake deposits. There is substantial variation in the water transmitting capabilities of these rocks. Some areas have basalt exposures that are essentially impermeable.

Pliocene volcanic rocks consist of basalt flows interbedded with pyroclastic rocks. Due to weathering and infilling of joints and fractures with fines, these rocks have low to moderate permeabilities and yield lesser amounts of groundwater to wells than the younger volcanic rocks.

Block faulting by northwestward-trending faults of late Pleistocene and possibly Holocene age is the dominant structural feature. At least three fault systems control the complex displacement structure. The basin is a fault trough in which a downthrown group of blocks is situated between two groups of elevated blocks. The volcanic rocks that underlie the valley have also been tilted and broken into several smaller blocks. Faulting has probably created shattered permeable zones for groundwater movement in the volcanic rocks. Within the sedimentary deposits faulting may have created barriers to groundwater movement.

Water levels in the basin are variable and are commonly dependent on the topographic elevation of a particular area, proximity to the Pit River, and localized pumping effects. In general, the northern portion of the basin consistently has the shallowest depths to groundwater (10 feet or less). Areas adjacent to the Pit River display more variable conditions.

The groundwater storage capacity to a depth of 400 feet is estimated to be 1,000,000 acre-feet (DWR 1963). DWR (1963) notes that the quantity of water that is useable is unknown.

Groundwater extraction, as estimated by DWR, is 19,000 acre-feet for municipal uses and 240 acre-feet for industrial uses.

The 1984 DWR study of the Eastern Upland area of Shasta County showed potential groundwater production limitations in the area north of State Highway 299 in the Eastern Upland planning area.

Major Sources of Recharge

Recharge to the Fall River Valley aquifer is mostly by subsurface flow and infiltration of precipitation into the alluvium. Average annual precipitation within the basin is estimated to be 17 to 27 inches in the valley and 29 to 43 inches in the upland areas to the west. DWR (2004) estimated recharge by deep percolation of applied water is estimated at 4,800 acre-feet.

The alluvial fans on the eastern margin of the valley are aquifer recharge areas. They consist of unconsolidated, poorly stratified silt, sand, and gravel to a thickness of 200 feet.

In the GAMA study, Moran et al. (2004) show evidence that subsurface flow also recharges the Fall River Valley basin. Two wells in Fall River Mills, in the distal portion of the groundwater flow field, have mantle helium components that show the effect of volcanic activity to the north indicating inflow into the basin from these areas.

At the north end of the Fall River Valley deposits from Holocene volcanic rocks serve as a major recharge area and feed numerous streams and springs. These springs have sustained flows measured at 1,400 to 2,000 cubic feet per second and provide the bulk of the base flow that sustains most of the streams, ponds, and lakes in the area. It has been speculated that the subsurface inflow for these springs originates 50 miles or more to the north at the Tule Lake/Klamath Lake basins and flows beneath and through the Medicine Lake Highlands. These springs have been extensively appropriated or diverted for irrigation and power development.

Land Use

Land use surveys were conducted within the basin by DWR in 1995. The foothills situated in the Eastern Upland region of Shasta County, which contains Fall River Valley basin contain a high percent of rangelands. The Fall River Valley basin is overlain with 57% agricultural land uses, 32% of which is rangeland. Table 4-60 provides details of the land uses within the basin.

Table 4-60. Land Use in the Fall River Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Field Crops	1,017	1.86
Grain and Hay	3,110	5.70
Pasture	17,422	31.94
Rice	1,321	2.42
Semiagricultural and Incidental	477	0.87
Truck, Nursery, and Berry Crops	822	1.51
Idle	6,679	12.24
Subtotal	30,847	56.55
Urban		
Urban—unclassified	417	0.76
Commercial	25	0.05
Industrial	79	0.15
Urban Landscape	9	0.02

Land Use	Acreage of Land Use	Percent of Land Use
Urban Residential	406	0.74
Vacant	79	0.15
Subtotal	1,015	1.86
Native		
Native Vegetation	17,421	31.94
Water	3,034	5.56
Riparian	2,233	4.09
Subtotal	22,689	41.59
Total	**54,551**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Although Shasta County has a groundwater ordinance, Fall River Valley itself, has no groundwater management plan. The largest extraction from the aquifer is for the paper mills and is 13 million gallons per day (mgd). There are also at least 470 wells (domestic and irrigation) drawing on the Fall River Valley aquifer (DWR 2004). The city of Fall River Mills relies solely on groundwater for its public water supply. Fall River Valley lies within the Pit River Watershed. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

The mineral quality of groundwater in the basin ranges varies primarily as a function of recharge water. Water from wells in the unconfined volcanic rocks within and adjacent to this basin is quite good with a calcium/magnesium bicarbonate character and low to moderate TDS. In the central portion of the basin, where lake deposits are thick, a sodium bicarbonate character is prevalent. In the western portion of the basin numerous wells produce groundwater with elevated iron concentrations. The concentration of TDS ranges from 115 to 232 mg/L, averaging 174 mg/L. (DWR 2004)

There are high concentrations of nitrate, manganese, ammonia, and phosphorus in localized areas throughout the basin. Some well waters have high iron concentrations (DWR 2004).

Funks Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Funks Creek Groundwater Basin is 5 square miles (3,000 acres) in size and is located in Glenn and Colusa Counties. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Funks Creek Groundwater Basin is located north of Antelope Valley and overlies the boundary of Glenn and Colusa Counties. The basin is north of a series of northeast trending faults and is bounded on all sides by Upper Cretaceous Marine deposits. The basin consists of Quaternary alluvial deposits and is drained to the east by Grapevine Creek and Funks Creek.

Major Sources of Recharge

Annual precipitation is approximately 18 inches and is the primary source of recharge for the basin.

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 17% of the basin, and native land use accounts for about 83% of the basin. Table 4-61 provides details on the distribution of land use throughout the Funks Creek Basin.

Table 4-61. Land Use in the Funks Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	511	16.96
Semiagricultural and Incidental	6	0.21
Subtotal	518	17.18
Native		
Native Vegetation	2,464	81.73
Water	33	1.09
Subtotal	2,496	82.82
Total	**3,014**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County adopted a groundwater management ordinance in 2000. Colusa County adopted a groundwater management ordinance in 1998. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

For the period of November 1, 1983 to June 30, 2003, the DPR reported 82 wells with verified pesticide detections and 27 wells with unverified pesticide detections in Glenn County. Funks Creek Basin is located within Glenn County. Three hundred and seventy-six wells were sampled for 117 pesticides (DPR 2003). The following compounds were detected and verified: atrazine (in 37 wells), bentazon (in 29 wells), DEA (in 4 wells), diuron (in 1 well), prometon (in 9 wells), and simazine (in 21 wells). The wells in the Funks Creek Basin that had pesticide detections could not be identified.

Goose Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Goose Valley groundwater basin is bounded to the west, north, and east by Pliocene basalt and to the south by Pleistocene basalt. It is located in a region of northwest trending faults in the mountains of eastern Shasta County. The basin is 4,210 acres (7 square miles) in size. The water-bearing formation in the basin consists of Quaternary lake deposits. Groundwater extraction for municipal and industrial uses is estimated by DWR (2004) to be 2 acre-feet.

Major Sources of Recharge

Recharge to the Goose Valley aquifer is mostly by infiltration precipitation into the alluvium. Annual precipitation ranges from 29–33 inches. DWR (2004) estimated recharge by deep percolation of applied water is estimated to be 1,100 acre-feet.

Land Use

Land use surveys were conducted within the basin by DWR in 1999. The foothills situated in the Eastern Upland region of Shasta County, which contains Goose Valley basin are comprise of 54% of rangelands and 8% native land uses. This basin is sparsely populated. Table 4-62 provides details of the land uses within the basin.

Table 4-62. Land Use in the Goose Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	422	10.01
Pasture	2,273	53.98
Rice	1,180	28.02
Semiagricultural and Incidental	11	0.25
Subtotal	3,885	92.27
Native		
Riparian	43	1.03
Native Vegetation	282	6.70
Subtotal	326	7.73
Total	**4,210**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

No water quality data are available for this basin.

Fandango Valley Subbasin—Goose Lake Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Fandango Valley Groundwater subbasin is part of the Goose Lake Valley Groundwater Basin which is located in Modoc County and extends north into Lake County, Oregon. The valley is approximately 47 miles long and 12 miles wide. It lies at an elevation of about 4,700 feet. Two thirds of the Goose Lake Valley is in Oregon. The basin is a down-faulted block with numerous bounding faults on the west and east side of the valley. Goose Lake occupies 144 square miles of the southern portion of the basin. The Fandango Valley subbasin is 18,500 acres (27 square miles) in size. It is located in Modoc County. The subbasin is an irregularly shaped groundwater basin that includes Fandango Valley and the area previously identified as the Willow Ranch subbasin (DWR 1963).

The following description of the hydrogeology in the Fandango Valley subbasin is taken from DWR Bulletin 118 (DWR 2004).

The primary water-bearing formations are Holocene sedimentary deposits (which include lake deposits, intermediate alluvium, and alluvial fan deposits) and Pleistocene near-shore deposits and lava flows. The following summary of water-bearing formations is from DWR (1963).

The lake deposits consist of unconsolidated interstratified clay and silty clay limited in extents to the Willow Ranch area. Water produced from these sediments may be of poor quality depending on the degree of alkalinity.

The intermediate alluvium consists of unconsolidated, poorly sorted silt and sand with lenses of gravel up to a thickness of 100 feet. The thickness of the deposits is considerably less for Fandango Valley. These zones are moderately permeable.

The alluvial fan deposits consist of unconsolidated to poorly consolidated, partially stratified sand, gravel, and silt with lenses of clay. These deposits are generally the most permeable of the valley sedimentary deposits. The eastside alluvial fans range up to 300 feet in thickness and are considered the most important groundwater source. The upper fan areas are moderately to highly permeable and, where saturated, can yield large amounts of water to wells. The mid- to lower fans are generally less permeable but contain confined zones yielding moderate amounts of water to wells. The alluvial fan deposits in Fandango Valley are considerably less in thickness due to their limited areal extent.

Near-shore deposits occur at the south end of the subbasin. The deposits are moderately to highly permeable and may yield large quantities of water to wells.

The Pleistocene volcanic rocks consist of highly jointed flat lying basalt flows ranging from 50 to 200 feet in thickness with interbedded scoriaceous zones and pyroclastic rocks. These rocks serve as a recharge zone and interfinger with valley sediments. In general these rocks are highly permeable and can yield large amounts of water to wells.

In Goose Valley Basin (including Lower Goose Valley and Fandange subbasins) groundwater storage to a depth of 500 feet is estimated to be 1,000,000 acre-feet (DWR 1963).

Major Sources of Recharge

The Fandango Valley subbasin is bound on the west by Goose Lake and on the west by the Warner Mountains. Goose Lake is an intermittent lake that gains water from the Fandango Valley groundwater subbasin. The water level fluctuates and the lake has been completely dry several times since the early 1900s (DWR 1963). All surface drainage in the Goose Lake Valley basin is to Goose Lake. Intermittent streams characterize the flanks of the Warner Mountains, where streams commonly are lost to infiltration of the permeable alluvial-fan deposits that they traverse after leaving the canyons. Willow, Lassen, Davis, and New Pine Creeks are the major streams of the Fandango basin. Most streams in the basin have their peak discharge in April or May, when they are fed by snowmelt.

The major sources of recharge to the Fandango Valley subbasin are infiltration of surface water and precipitation. Upland recharge areas consist of the permeable basalt flows of Pliocene to Pleistocene age. Precipitation and surface runoff infiltrates the basalt flows and percolates towards the valley, and along Willow Creek, recharging valley sediments. Most of the recharge to deeper aquifers along the east side of the California portion of Goose Lake Valley is derived from infiltration of surface water, generally along the foothill portions of stream channels. DWR estimates Annual precipitation ranges from 17 to 19 inches in the Willow Ranch area and from 19 to 23 inches in Fandango Valley.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land uses made up 27% of the basin, native vegetation made up 73% of the basin and only 0.19% of the basin was urban. Land use details are displayed in Table 4-63.

Table 4-63. Land Use in the Fandango Subbasin*

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	32	0.18
Grain and Hay	290	1.57
Pasture	4,445	24.12
Semiagriculture and Incidental	129	0.70

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	4,896	26.57
Urban		
Urban Residential	35	0.19
Subtotal	35	0.19
Native		
Native Vegetation	10,048	54.52
Water	1,644	8.92
Riparian	1,807	9.81
Subtotal	13,500	73.25
Total	**18,431**	**100.00**

*The portion of Goose Valley that is in Oregon is heavily used for agricultural purposes and water is diverted from the tributary streams and pumped from groundwater in order to irrigate crops.

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the ordinance requires an export permit for transfers of water out of the basin (DWR 2004). Small communities exist on Deer Creek and New Pine Creek. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium bicarbonate type waters occur throughout the basin. Sodium bicarbonate waters are found below 200 feet in a three square mile area east of Goose Lake and south of New Pine Creek. The concentration of TDS averages 183 mg/L and ranges from 66 to 528 mg/L.

Lower Goose Lake Valley Subbasin—Goose Lake Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Lower Goose Lake Valley Groundwater subbasin is part of the Goose Lake Valley Groundwater Basin which is located in Modoc County and extends north into Lake County, Oregon. The valley is approximately 47 miles long and 12 miles wide. It lies at an elevation of about 4,700 feet. Two thirds of the Goose Lake Valley is in Oregon. The basin is a down-faulted block with numerous bounding faults on the west and east side of the valley. Goose Lake occupies 144 square miles of the southern portion of the basin. The Lower Goose Lake Valley subbasin is 36,000 acres (56 square miles) in size. It is bounded on the north by Goose Lake, on the east by Pliocene and Tertiary basalt and Tertiary intrusive rocks of the Warner Mountains, and on the west by Pliocene basalt of the Modoc Plateau.

The following description of the hydrogeology in the Lower Goose Lake Valley subbasin is taken from DWR Bulletin 118 (DWR 2004).

The primary water-bearing formations are Holocene sedimentary deposits (which include lake deposits, intermediate alluvium, and alluvial fan deposits), Pleistocene near-shore deposits, Pliocene to Pleistocene lava flows, and to a lesser extent, the Plio-Pleistocene Alturas Formation. The following summary of water-bearing formations is from DWR (1963).

The lake deposits consist of unconsolidated interstratified clay and silty clay. Water produced from these sediments may be of poor quality depending on the degree of alkalinity. Thickness of the deposits ranges up to 1,000 feet. The intermediate alluvium consists of unconsolidated, poorly sorted silt and sand with lenses of gravel up to a thickness of 100 feet. These zones are moderately permeable.

The alluvial fan deposits consist of unconsolidated to poorly consolidated, partially stratified sand, gravel, and silt with lenses of clay. These deposits are generally the most permeable of the valley sedimentary deposits. The eastside alluvial fans range up to 300 feet in thickness and are considered the most important groundwater source. The upper fan areas are moderately to highly permeable and, where saturated, can yield large amounts of water to wells. The mid- to lower fans are generally less permeable but contain confined zones yielding moderate amounts of water to wells. The west side fans, ranging in thickness to 100 feet, are less permeable resulting in low to moderate well yields.

Near-shore deposits occur at the south end of the subbasin and overlie the basin in the southwest trending towards the northeast subbasin boundary. The deposits are moderately to highly permeable and may yield large quantities of water to wells.

The Pleistocene volcanic rocks consist of highly jointed flat lying basalt flows ranging from 50 to 200 feet in thickness with interbedded scoriaceous zones and pyroclastic rocks. In the surrounding upland, these rocks serve as a recharge zone; in the valley they interfinger with valley sediments and act as a forebay to water-bearing deposits. In general these rocks are highly permeable and can yield large amounts of water to wells.

The Plio-Pleistocene volcanic rocks consist of highly jointed basalt flows with some zones of scoria and interbedded pyroclastic rocks. The deposits range up to 500 feet in thickness. These rocks are generally highly permeable and are areas of recharge where exposed at the ground surface. Flows from the west side of the basin contain numerous permeable zones that likely provide large quantities of water to wells. On the east side of the basin, multiple flows of fractured lava are interbedded within the valley sedimentary deposits. Wells penetrating these rocks yield moderate to high quantities of water.

The Alturas Formation consists of slightly consolidated, well-bedded, tuffaceous sandstone and occurs at depth in the basin separating younger and older lava flows. The deposits are moderately permeable and may provide moderate amounts of confined water to deep wells. Thickness of the formation ranges up to 500 feet. In the Goose Valley Basin (including Lower Goose Valley and Fandango subbasins) groundwater storage to a depth of 500 feet is estimated to be 1,000,000 acre-feet (DWR 1963).

Fall River is the primary stream draining the northern and central-valley areas, and the Pit River is the primary stream in the easterly and southerly portion of the basin. These rivers converge at the southwestern corner of the valley near Fall River Mills and flow westward out of the valley.

Estimates of groundwater extraction for the Goose Lake Basin (including Lower Goose Lake Valley and Fandango subbasins) are based on a survey conducted by the DWR during 1997. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal /industrial uses are 10,000, and 25 acre-feet respectively. Information about possible sources of contaminants could not be identified.

Major Sources of Recharge

Lower Goose Lake Valley is bounded on the north by Goose Lake, which is an intermittent lake. The lake gains water from the Lower Goose Lake Valley subbasin. The water level fluctuates and the lake has been completely dry several times since the early 1900s (DWR 1963). Davis Creek flows into the subbasin, toward Goose Lake, from the Warner Mountains. At the southern end of the subbasin, tributary streams flow south to the North Fork Pit River, exiting the subbasin.

The major sources of recharge to the Lower Goose Lake Valley subbasin are precipitation and surface runoff from the Warner Mountains. Upland recharge areas consist of permeable basalt flows of Pliocene to Pleistocene age. Precipitation and surface runoff infiltrates the basalt flows and percolates towards the valley recharging valley sediments. Most of the recharge to deeper aquifers along the east side of the California portion of Goose Lake Valley is derived from infiltration of surface water, generally along the foothill portions of stream channels. A relatively large portion of precipitation occurring along the west side of the valley infiltrates upland recharge areas (DWR 1963). Annual precipitation ranges from 15 to 17 inches. DWR estimates that recharge to Goose Lake Basin from deep percolation from applied water is 1,600 acre-feet per year.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. The majority (75%) of the land in Lower Goose Lake Valley is undeveloped. Twenty-five percent is agricultural and 0.28% is urban. Table 4-64 provides a more detailed description of the land use.

Table 4-64. Land Use in the Lower Goose Lake Valley Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Deciduous Fruits and Nuts	0.28	0.001
Grain and Hay	355	0.99
Pasture	8,452	23.51
Semiagricultural and Incidental	111	0.31
Subtotal	8,918	24.80
Urban		
Industrial	26	0.07
Urban Landscape	3.5	0.01
Urban Residential	68	0.19
Vacant	2.6	0.01
Subtotal	100	0.28

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Riparian	1,350	3.75
Native Vegetation	18,924	52.63
Water	6,396	17.79
Barren and Wasteland	266	0.74
Subtotal	26,936	74.92
Total	**35,954**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the ordinance requires an export permit for groundwater transfers out of the basin (DWR 2004). This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium bicarbonate type waters occur throughout the basin. The concentration of TDS averages 183 mg/L and ranges from 66 to 528 mg/L (DWR 2004).

Grays Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Grays Valley groundwater basin is an alluvial valley located in southwest Lassen County. It resides at the western base of Crater Lake Mountain and is 5,440 acres (8 square miles) in size. The basin is bounded by basalt of Crater Lake Mountain to the east. The basin is bounded on all other sides by Pleistocene basalt of Bogard Buttes, Cal Mountain, and Cone Mountain. Highway 44 traverses the basin.

Major Sources of Recharge

Recharge to the basin is from precipitation, lake infiltration, and surface runoff. The average annual precipitation in the basin ranges from 19 to 21 inches. A lake resides in the northwest corner of the basin.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. Grays Valley is rather small and all of the land uses in are Native (Table 4-65).

Table 4-65. Land Use in the Long Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	4,750	87.30
Water	690	12.70
Total	**5,440**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications within Grays Valley Basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

No data are available for water quality.

Grizzly Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Grizzly Valley Groundwater Basin lies within a down-dropped graben bounded to the northeast by Grizzly Valley Fault and to the southwest by a series of northwest trending faults. Hot Springs Fault appears to transect the basin from the southeast to the northwest. The basin is bounded to the north by Miocene volcanic rocks and to the south by Paleozoic marine sediments, Mesozoic granitic rocks, recent volcanics, and Tertiary intrusive rocks. Grizzly Creek drains the valley and is tributary to the Middle Fork Feather River. Grizzly Creek drains the valley and is tributary to the Middle Fork Feather River. Other creeks in the basin are Freeman, Little Grizzly, Blakeless, Emigrant, Lovejoy, and Cow. The area of Grizzly Valley basin is 13,440 acres and is located in Plumas County.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation and stream infiltration. Annual precipitation ranges from 29 to 37 inches, increasing to the west.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Native land accounts for about 99.9% of the basin. Table 4-66 provides details of the land uses within the basin.

Table 4-66. Land Use in the Grizzly Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Urban Residential	10	0.10
Subtotal	10	0.10
Native		
Native Vegetation	8,390	62.40
Riparian	1,440	10.70
Water	3,600	26.80
Subtotal	13,430	99.90
Total	**13,440**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications, water agencies, or urban areas within the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

High Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The High Valley Basin is 4 square miles in size and is located in Lake County. The following description of the physiography and hydrogeology in the High Valley Basin is taken from DWR Bulletin 118 (2004).

High Valley Basin is a small, poorly drained, isolated valley in the Coast Ranges. It is nearly a closed basin, with the only outlet being the narrow gorge of Schindler Creek in the southeast corner. The valley consists of a flat alluvial plain about 3 miles long and 1 mile wide, surrounded by a narrow band of high, steeply sloping hills. The north, west, and south boundary of the High Valley Basin is generally defined as the contact between the Jurassic-Cretaceous Franciscan Formation and the valley alluvium. Baldy Mountain is located to the west, and High Valley Ridge borders the valley to the north. Quaternary Holocene volcanics border the basin to the east.

The aquifer system in High Valley Basin is comprised primarily of Quaternary alluvial deposits and Holocene volcanic deposits. The alluvium overlies a confined volcanic aquifer of Holocene age. Below the volcanic aquifer are older alluvial deposits about which there is little information.

The Quaternary alluvium consists of up to 100 feet of fine-grained lake deposits that confine an underlying volcanic aquifer. The permeability of the alluvium is generally low. The central part of the alluvial plain is bordered by alluvial fans containing coarser grained material.

Holocene volcanics likely originated from the vicinity of Round Mountain located to the east. These volcanics, which also dammed the ancestral valley, were later buried in the central portion of the valley by fine-grained alluvium reducing potential recharge on the valley floor. Most irrigation wells in the valley tap the fine-grained alluvium. Irrigation wells drilled in the volcanic aquifer system were initially productive, but after a few seasons of operation, production was reduced. One well was reported to yield about 1,000 gpm, reducing to a yield of only about 200 gpm after 4 years of production. Thickness of the formation is unknown.

Information with respect to the hydrogeology of the basin is limited. Little is known in regards to the lithology of the deeper alluvium and it’s believed that the extents of the alluvium may be several miles to the east underneath the younger volcanics.

The storage capacity is estimated to be 9,000 acre-feet for a saturated depth interval of 10–100 feet. Usable storage capacity is estimated to be 900 acre-feet.

Estimates of groundwater extraction for the High Valley Basin are based on a survey conducted by the DWR in 1995. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 78 and 210 acre-feet, respectively. Deep percolation from applied water is estimated to be 33 acre-feet.

Major Sources of Recharge

The source of recharge in High Valley Basin is from precipitation within the drainage area. Infiltration likely occurs at the perimeter of the valley in the alluvial fans. Annual precipitation in the valley ranges from 27 to 35 inches, decreasing to the east.

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 16% of the basin, urban land use accounts for less than 2% of the basin, and native land use accounts for about 82% of the basin. Table 4-67 provides details on the distribution of land use throughout the High Valley Basin.

Table 4-67. Land Use in the High Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	3	0.11
Idle	179	7.61
Pasture	119	5.05
Semiagricultural and Incidental	22	0.95
Vineyards	64	2.71
Subtotal	388	16.44
Urban		
Industrial	36	1.54
Subtotal	36	1.54
Native		
Riparian	38	1.59
Native Vegetation	1,883	79.86
Water	13	0.57
Subtotal	1,934	82.02
Total	**2,358**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). The only public water agency in the High Valley Basin is Clearlake Oaks CWD. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater in the basin consists of magnesium bicarbonate type waters. TDS ranges from 480 to 745 mg/L, averaging 598 mg/L. Impairments to water quality include locally high ammonia, phosphorus, chloride, iron, and manganese. High boron may be an issue for agricultural uses. (DWR 2004, 1975.)

Hot Springs Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of Hot Springs Valley Basin is 4 square miles (2,400 acres) and it is located in Modoc and Shasta Counties. The following description of the hydrogeology in the basin is taken from DWR Bulletin

118 (2004). The Hot Springs Valley Groundwater Basin is a northwest trending valley of Quaternary alluvium. The basin is bounded to the north, northeast, and northwest by Tertiary basalt of Big Valley Mountain and to the east and west by Recent basalt.

Based on 1995 and 1997 DWR surveys of land use and sources of water, groundwater extraction for municipal and industrial uses in the basin is estimated to be 1 acre-foot. Deep percolation of applied water is estimated to be 41 acre-feet.

The total depth of domestic wells in the basin range from 55 to 380 feet, with an average of 164 feet, based on 7 well completion reports. The single municipal/irrigation well completed in the basin is reported to have a total depth of 230 feet. No yield information is available for these wells. (DWR 2004.)

Major Sources of Recharge

Precipitation is the major source of recharge. Annual precipitation ranges from 19 to 27 inches, increasing to the north.

Land Use

Land use surveys were conducted within the basin by DWR in 1995 and 1997. Agricultural land use accounts for about 23% of the basin and native land accounts for about 77% of the basin. Table 4-68 provides details on the distribution of land use throughout the Hot Springs Valley Basin.

Table 4-68. Land Use in the Hot Springs Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Idle	332	13.79
Pasture	230	9.58
Subtotal	562	23.36
Native		
Native Vegetation	1,839	76.46
Water	4	0.18
Subtotal	1,843	76.64
Total	**2,405**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998 and Siskiyou County adopted a groundwater management ordinance in 1998. A key element of both of the county ordinances is the requirement of an export permit for groundwater transferred out of the basin (DWR 2004). There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Humbug Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

Humbug Valley is a small down-dropped area within the Penman Peak-Beckwourth Peak northeast of Mohawk Valley. The valley is approximately 6 miles long and 3 miles wide. The valley is bounded to the north by Pliocene volcanic rocks of Penman Peak, to the southeast by Miocene volcanic rocks of Beckwourth Peak, and to the northeast by Mesozoic granitic rocks. The floor of the river canyon is composed of fairly flat alluvium and sloping lake deposits at the western end of the valley. Middle Fork Feather River flows southwesterly through the valley to Mohawk Valley. Humbug Creek and Willow Creek are major tributaries to Middle Fork Feather River. The basin is located in Plumas County and is 9,980 acres (16 square miles) in size.

The following information regarding the hydrogeology of Humbug Valley basin is taken from DWR Bulletin118 (2004). The water-bearing formations of Humbug Valley are probably similar to those of Mohawk Valley. The primary water-bearing formations of Mohawk Valley are Holocene sedimentary deposits and Pleistocene lake deposits.

Holocene sedimentary deposits include alluvial fans and intermediate alluvium. Alluvial fans consist of unconsolidated gravel, sand, and silt with minor clay lenses. The fan deposits coalesce or interfinger with lake and alluvial deposits. Specific yield ranges from 8 to 17%. Intermediate alluvium consists of unconsolidated silt and sand with lenses of clay and gravel. Specific yield is estimated to range from 5 to 25%. Pleistocene Lake deposits consist of slightly consolidated, bedded sand, silt, and diatomaceous clay. Specific yield ranges from 1 to 25%. DWR (1963) estimates storage capacity to be 76,000 acre-feet to a depth of 100 feet.

DWR (2004) estimated groundwater extraction and percolation of applied water based on a 1997 survey. Groundwater extraction for municipal and industrial uses is estimated to be 200 acre-feet. Deep percolation of applied water is estimated to be 200 acre-feet.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation, infiltration of irrigation water and stream infiltration. Annual precipitation in the valley ranges from 23 to 29 inches, increasing to the southwest. Middle Fork Feather River flows southwesterly through the Humbug Valley to Mohawk Valley. Humbug Creek and Willow Creek are major tributaries to Middle Fork Feather River. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 4% of the basin, urban land uses account for 8% of the basin and native land accounts for about 88% of the basin. Table 4-69 provides details of the land uses within the Humbug Valley Basin.

Table 4-69. Land Use in the Humbug Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	430	4.32
Subtotal	430	4.32
Urban		
Commercial	30	0.30
Industrial	70	0.70
Urban Landscape	10	0.10
Urban Residential	690	6.93
Subtotal	800	8.03
Native		
Riparian	120	1.20
Native Vegetation	8,590	86.24
Water	20	0.20
Subtotal	8,730	87.65
Total	**9,960**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for this basin. The cities of Portola and Delleker are located in the basin. The public water agencies in the basin are City of Portola WSA and Grizzly Lake Resort ID. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

The CDPH sampled municipal wells as required by Title 22 from 1994 to 2000. Sampling was completed for inorganics (11 wells), nitrates (14 wells), pesticides (2 wells), volatile organic compounds (2 wells), and radioactive elements (4 wells). There were no confirmed detections above the MCLs.

Indian Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Indian Valley aquifer system is 46 square miles in size and is located in Plumas County. The following description of the hydrogeology of the basin is taken from DWR Bulletin 118 (2004).

The Indian Valley Groundwater Basin is an irregular shaped basin bounded by Paleozoic to Mesozoic marine, volcanic, and metavolcanic rocks. The basin includes Genessee Valley, Indian Valley, and Bucks Valley. Indian Creek flows south and drains the basin at the southwest corner.

Storage capacity is estimated to be 100,000 acre-feet for a saturated depth interval of 10–210 feet.

Based on a 1997 DWR survey of land use and sources of water, groundwater extraction for municipal and industrial uses is estimated to be 100 acre-feet.

Major Sources of Recharge

Deep percolation of applied water is estimated to be 2,600 acre-feet. Annual precipitation ranges from 31 to 43 inches, increasing to the southwest. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 39% of the basin, urban land use accounts for about 4% of the basin, and native land use accounts for about 57% of the basin. Table 4-70 provides details on the distribution of land use throughout the Indian Valley Basin.

Table 4-70. Land Uses in the Indian Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	11,401	38.76
Semiagricultural and Incidental	106	0.36
Subtotal	11,507	39.12
Urban		
Commercial	103	0.35
Industrial	128	0.44
Urban Landscape	29	0.10
Urban Residential	778	2.64
Vacant	59	0.20
Subtotal	1,097	3.73

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Barren and Wasteland	185	0.63
Riparian	403	1.37
Native Vegetation	15,975	54.31
Water	246	0.84
Subtotal	16,809	57.15
Total	**29,413**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for the Indian Valley Basin. No public or private water agencies exist within the basin (DWR 2004).

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater in the Indian Valley Basin is sampled for miscellaneous water quality parameters by DWR at 4 wells and by the CDPH at 9 wells. Groundwater sampling performed under the requirements of the CDPH Title 22 program from 1994 through 2000 tested for primary and secondary inorganics, radiologicals, nitrates, pesticides, VOCs, and SVOCs. One well of 14 sampled showed concentrations above the MCLs for secondary inorganics. Concentrations above the MCL for the other constituents were not detected (DWR 2004).

Jess Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Jess Valley groundwater basin is located in Modoc County and is 6,700 acres (10 square miles) in size. The west side of the basin is bounded by Miocene basalt and, to a much lesser extent, Tertiary pyroclastic rocks. The basin is bounded on all other sides by Tertiary pyroclastic rocks. Jess Valley Basin consists of Quaternary alluvium and lake deposits. It drains to the west.

No hydrogeologic information is available for this basin.

DWR estimates groundwater extraction for municipal and industrial uses to be 2 acre-feet. (DWR 2004)Major Sources of Recharge

Recharge to the basin is from precipitation, irrigation infiltration, and stream infiltration. The average annual precipitation is about 17 inches (DWR 2004). Deep percolation of applied water is estimated by DWR (2004) to be 830 acre-feet. East Creek and Mill River influence the groundwater in the Jess Valley Basin.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. The Jess Valley Basin is overlain with 53% agricultural land use, almost all of which is rangeland (pasture). Table 4-71 provides details of the land uses within the basin.

Table 4-71. Land Use in the Jess Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	3,571	53.26
Semiagricultural and Incidental	16	0.24
Subtotal	3,587	53.49
Urban		
Urban Residential	38	0.57
Subtotal	38	0.57
Native		
Riparian	213	3.17
Native Vegetation	2,868	42.77
Subtotal	3,081	45.94
Total	**6,705**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. Groundwater ordinances generally limit the volume of groundwater that can be pumped and/or exported from the basin. A key element of the Modoc County ordinance requires an export permit for groundwater transferred out of the basin (DWR 2004). Public water agencies involved with the basin are the California Pines Community Service District, and Hot Springs Valley Irrigation District. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Joseph Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Joseph Creek Basin is 7 square miles (4,450 acres) in size and is located in Modoc County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Joseph Creek Groundwater Basin is located south of Goose Lake Groundwater Basin and west of the Warner Mountains. The basin consists of Quaternary Pleistocene non-marine deposits and Holocene alluvial deposits. The alluvial deposits are located at the southern and western boundaries of the basin along North Fork Pit River and Parker Creek. Alluvial deposits are also located centrally and at the far eastern extents of the basin. The basin is bounded by Tertiary volcanic rocks of the Warner Mountains to the north, east, and south and Pleistocene pyroclastic rocks and basalt to the south and west respectively. Additional hydrogeologic information was not available from DWR for the water-bearing formations, groundwater level trends, or groundwater storage.

Based on a 1997 DWR survey of land use and sources of water, groundwater extraction for agricultural use is estimated to be 1,300 acre-feet. Well completion reports in the basin showed the yield for 1 municipal/irrigation well as 400 gal/min. The total depth of the single municipal/irrigation well in the basin is 230 feet (DWR 2004).

Major Sources of Recharge

Deep percolation of applied irrigation water is estimated to be 140 acre-feet. Annual precipitation ranges from 15 to 19 inches, increasing to the east. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 21% of the basin, and native land accounts for about 79% of the basin. Table 4-72 provides details on the distribution of land use throughout the Joseph Creek Basin.

Table 4-72. Land Use in the Joseph Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	909	20.41
Semiagricultural and Incidental	12	0.27
Subtotal	921	20.67
Native		
Riparian	91	2.04
Native Vegetation	3,431	77.00
Water	13	0.29
Subtotal	3,535	79.33

Total	**4,456**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the ordinance requires an export permit for groundwater transfers out of the basin (DWR 2004). There are no public or private water agencies in the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Lake Almanor Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Lake Almanor Valley Basin is 11 square miles in size and is located in Plumas County. The basin is located along the northwest shore of Lake Almanor and consists of Quaternary lake deposits and Pleistocene non-marine sediments. The basin is bounded by Lake Almanor to the southeast and bounded on all other sides by Pliocene basalt (DWR 2004).

The storage capacity is estimated to be 45,000 acre-feet for a saturated depth interval of 10–210 feet (DWR 2004). According to DWR Bulletin 118 (2004), hydrologic information is not available for descriptions of the water-bearing formations or groundwater level trends in the basin.

Based on 18 well completion reports, the average total depth of domestic wells in the basin is 55 feet, with a range from 19 to 106 feet. The total depth of the 2 municipal/irrigation wells reported in the basin is 94 feet and 100 feet. (DWR 2004.)

A 1997 DWR survey of land use and sources of water indicates that groundwater extraction for municipal and industrial uses in the Lake Almanor Valley Basin is estimated at 740 acre-feet.

Major Sources of Recharge

Annual precipitation in the basin is the primary source of recharge and ranges from 31 to 37 inches, increasing to the northwest. Deep percolation of applied water is estimated at 690 acre-feet.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 19% of the basin, urban land use accounts for about 18% of the basin, and native land use accounts for about 62% of the basin. Table 4-73 provides details on the distribution of land use throughout the Lake Almanor Valley Basin.

Table 4-73. Land Use in the Lake Almanor Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	1,386	19.37
Semiagricultural and Incidental	3	0.04
Subtotal	1,389	19.41
Urban		
Urban	132	1.85
Commercial	56	0.78
Industrial	319	4.45
Urban Landscape	3	0.05
Urban Residential	625	8.74
Vacant	167	2.33
Subtotal	1,302	18.20
Native		
Riparian	399	5.58
Native Vegetation	3,458	48.34
Water	606	8.47
Subtotal	4,463	62.39
Total	**7,154**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for Lake Almanor Valley Groundwater Basin. Chester PUD is the sole public water agency in the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium bicarbonate is the predominant groundwater type in the basin. TDS concentrations range from 53 to 260 mg/L, averaging 105 mg/L. Groundwater in the basin has locally high copper, iron, lead, manganese, calcium and boron. (DWR 2004.)

Lake Britton Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Lake Britton Area groundwater basin is located within a west-northwest trending valley in a region of several northwest trending faults. The basin is bounded to the south by Pleistocene basalt, to the west by Tertiary andesite, and to the north by Miocene basalt and Pliocene andesite (Gay 1968; Lydon 1969). The valley is drained by the Pit River. The basin is 14,060 acres (22 square miles) in size and is located in eastern Shasta County.

Groundwater extraction for municipal and industrial uses is estimated by DWR (2004) to be 5 acre-feet.

The 1984 DWR study of the Eastern Upland area of Shasta County showed potential groundwater limitations in the area north of State Highway 299 in the Eastern Upland planning area.

Major Sources of Recharge

Recharge to the Lake Britton Area aquifer is mostly by infiltration of precipitation into the alluvium. Annual precipitation ranges from 21-43 inches, increasing to the east. Estimated recharge by deep percolation of applied water is 10 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1999. Almost all of the land uses in the Lake Britton basin are Native land uses. Only 0.9% is urban and 0.3% is agricultural. Table 4-74 provides details of the land uses.

Table 4-74. Land Use in the Lake Britton Area Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	44	0.32
Subtotal	44	0.32
Urban		
Urban—unclassified	29	0.21
Urban Landscape	93	0.66
Urban Residential	6	0.04
Subtotal	128	0.91
Native		
Native Vegetation	12,508	88.95
Water	1,381	9.82
Subtotal	13,889	98.78
Total	**14,061**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county.

Along with Shasta County, the Burney Water District is the only water agency that manages the water in the Lake Britton Area basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Last Chance Creek Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Last Chance Valley Groundwater Basin is a narrow east/west trending basin located south of Honey Lake. The basin is bounded to the south by Tertiary pyroclastic rocks and to the north by Miocene volcanics, Mesozoic granitic rocks, and Tertiary pyroclastic rocks. Eocene basalt borders the basin in the west. Last Chance Creek drains the basin to the west. The basin is 4,660 acres (7 square miles) in size and is located in northeastern Plumas County.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation and stream infiltration. Annual precipitation ranges from 17 to 23 inches, increasing to the west. Last Chance Creek drains the basin to the west.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. There is no agricultural land in this basin (Table 4-75).

Table 4-75. Land Use in the Last Chance Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	4,190	90.11
Riparian	460	9.89
Total	**4,650**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications. There are no know water agenciesor urban areas within the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Little Indian Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Little Indian Valley Basin is bounded to the northeast by the East Park Reservoir and on all other sides by Mesozoic lower Cretaceous marine sedimentary rocks and the Knoxville Formation. The basin consists of Quaternary stream terrace deposits. Faulting may transect the basin. The aquifer system is 2 square miles in size and is located in Lake County. Hydrogeologic information, groundwater level trends, and groundwater storage data are not available for the water bearing formations. Based on a 1993 DWR survey of land use and sources of water, groundwater extraction for municipal and industrial uses is estimated to be 34 acre-feet. (DWR 2004.)

Major Sources of Recharge

Annual precipitation is approximately 21 inches. Deep percolation of applied water is estimated to be 25 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 25% of the basin, urban land use accounts for about 38% of the basin, and native land use accounts for about 37% of the basin. Table 4-76 provides details on the distribution of land use throughout the Little Indian Valley Basin.

Table 4-76. Land Use in the Little Indian Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	305	24.06
Semiagricultural and Incidental	10	0.79
Subtotal	316	24.86
Urban		
Urban Residential	480	37.81
Subtotal	480	37.81
Native		
Riparian	6	0.51
Native Vegetation	466	36.71
Water	1	0.11
Subtotal	474	37.33
Total	**1,270**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). No public or private water agencies are located within the Little Indian Valley Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

There is insufficient groundwater quality information available to characterize this basin (DWR 2004). CDPH sampled only one well for inorganic and one well for nitrates between the years of 1994 and 2000.

Long Valley Basin (5-31)

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Long Valley Basin is 4 square miles in size and is located in Lake County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

Long Valley Groundwater Basin is located within a narrow elongated valley northeast of Clear Lake. The basin is bounded on most sides by the Franciscan Formation. A small portion of the southern boundary consists of Quaternary volcanic rocks. The valley is drained by Long Valley Creek, which is tributary to North Fork Cache Creek. Groundwater is developed in Quaternary alluvium and, to a limited extent, Quaternary terrace deposits.

Estimates of groundwater extraction are based on a survey conducted by the DWR in 1995. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 760 and 23 acre-feet respectively.

Major Sources of Recharge

Recharge to the basin is from precipitation with annual precipitation ranging from 27 to 33 inches, increasing to the west. Deep percolation from applied water is estimated to be 210 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 32% of the basin, urban land use accounts for about 6% of the basin, and native land use accounts for about 61% of the basin. Table 4-77 provides details on the distribution of land use throughout the Long Valley Basin.

Table 4-77. Land Use in the Long Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	44	1.56
Grain and Hay	523	18.68
Idle	206	7.36
Semiagricultural and Incidental	20	0.71
Truck, Nursery, and Berry Crops	117	4.16
Subtotal	910	32.46
Urban		
Urban Residential	175	6.25
Subtotal	175	6.25

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	1,715	61.23
Water	2	0.05
Subtotal	1,717	61.29
Total	**2,802**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance for Long Valley Basin in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). County of Lake is the only public water agency within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Long Valley Basin (5-44)

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004). The Long Valley groundwater basin (5-44) is an alluvial filled valley located in eastern Modoc and Lassen Counties. Total acreage is 1,090 acres (2 square miles). The basin is bounded on the west side by a north/south trending fault. The basin is bounded on the northern half of the west side of the valley by Tertiary pyroclastic rocks and on all other sides by Miocene basalt.

Major Sources of Recharge

The primary source of groundwater recharge is precipitation and surface runoff. The average annual precipitation in the basin ranges from 25 to 27 inches. (DWR 2004.)

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. According to the survey, native vegetation is the only category of land use in the Long Valley Basin 5-44.

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. Groundwater ordinances generally limit the volume of groundwater that can be pumped and/or exported from the basin. A key element of the Modoc County ordinance requires an export permit for groundwater transferred out of the basin (DWR 2004).

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality datafor this basin could not be identified.

Lower Lake Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Lower Lake Basin is bounded on the south by Plio-Pleistocene Cache Formation, Tertiary bedrock, and rocks of the Great Valley Sequence; on the north by the Cache Formation and Quaternary volcanics; and on the east by Tertiary rock of the Martinez and Tejon formations. The area of the basin is 4 square miles and it is located in Lake County. (DWR 2004.)

The following description of the hydrogeology in the Lower Lake Basin is taken from DWR Bulletin 118 (2004). Lower Lake Basin is located at the southeast end of Clear Lake and includes the alluvial plains of Cache, Herndon, and Seigler Canyon Creeks. Copsey Creek also drains to Cache Creek from Excelsior Valley located to the south. The basin is Surficial Cache Formation and Martinez Formation deposits are located within the middle third of the basin north and northeast of the city of Lower Lake. The aquifer system of Lower Lake Basin is primarily composed of deposits of Quaternary alluvium and the Plio-Pleistocene Cache Formation.

Alluvial deposits in the basin are approximately 50–75 feet thick and consist of clay, silt, and sand, with some gravel. Irrigation wells constructed in the vicinity of alluvial deposits yield between 400 and 600 gpm with little drawdowns. The alluvial plain of Herndon Creek likely consists of clay, clay and gravel, and some interbedded gravel stringers or layers. Wells installed to depths of approximately 75 feet yield up to 250 gpm with about 40 feet of drawdown.

The Cache Formation is primarily composed of gravel, silt, and sand with the upper most sediments consisting of water-laid tuffs and tuffaceous sands intercalated with clay, marl, pebbly limestone, and diatomite. The formation underlies younger alluvial deposits over a region of approximately two-thirds of the basin. The permeability in the formation is variable but generally low. Most of the strata are too high in clay or silt. Depth of the formation is unknown. Well yields are reported to range between 150 and 240 gpm.

Storage capacity is estimated to range from 3,000 to 4,000 acre-feet. Additional storage capacity is available as part of the Cache Formation; however, thickness and specific yield of that formation is unknown.

Estimates of groundwater extraction for Lower Lake Basin are based on a survey conducted by the DWR in 2001. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 78 and 210 acre-feet respectively. Deep percolation from applied water is estimated to be 33 acre-feet.

Major Sources of Recharge

Groundwater recharge is derived from precipitation and from seepage from Herndon Creek and Clear Lake. Recharge also likely occurs from Copsey and Seigler Canyon Creeks. Recharge of groundwater in the Cache formation is likely derived from the infiltration of rain that falls on the outcrop area. Annual precipitation in the basin is approximately 27 inches. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 7% of the basin, urban land use accounts for about 27% of the basin, and native land accounts for about 66% of the basin. Table 4-78 provides details on the distribution of land use throughout the Lower Lake Basin.

Table 4-78. Land Use in the Lower Lake Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	91	3.76
Grain and Hay	18	0.76
Idle	19	0.80
Semiagricultural and Incidental	3	0.11
Vineyards	31	1.29
Subtotal	162	6.73
Urban		
Commercial	52	2.18
Industrial	6	0.25
Urban Landscape	5	0.20
Urban Residential	572	23.76
Vacant	11	0.44
Subtotal	645	26.83
Native		
Riparian	4	0.16
Native Vegetation	1,371	57.00
Water	223	9.28
Subtotal	1,598	66.44

Land Use	Acreage of Land Use	Percent of Land Use
Total	**2,406**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance for Lower Lake Basin in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). Highlands Mutual Water Company is a private water agency within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Bicarbonate type waters with mixed cationic character are found in the basin. TDS concentrations range from 290 to 1,230 mg/L, averaging 568 mg/L. Groundwater in the basin has localized high iron, manganese, calcium, sodium, ASAR, sulfate, and TDS. High boron concentrations may be an issue for irrigation (DWR 2004). Groundwater sampling performed under the requirements of the CDPH Title 22 program from 1994 through 2000 tested for primary and secondary inorganics, radiologicals, nitrates, and pesticides. Two wells of 3 showed concentrations above the MCLs for secondary inorganics. There were no detections above MCLs for other constituents.

McCloud Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The McCloud Area Groundwater Basin is located at the base of Mount Shasta on the southeast slope. It is in Siskiyou County and is 21,320 acres (33 square miles) in size. Elevation of the basin ranges from 3,060 feet mean sea level in the south to 6,000 feet mean sea level in the north. The basin is bounded to the west by Pleistocene volcanic rocks and glacial deposits of Mount Shasta. The basin is bounded to the north by Pliocene basalt, to the east by Pliocene basalt and Pleistocene volcanic rocks, and to the south by Paleozoic marine sedimentary and metasedimentary rocks (DWR 2004).

DWR estimated groundwater extraction for agriculture to be 3 acre-feet. Municipal and industrial use is approximately 420 acre-feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (49 to 55 inches/year), irrigation infiltration, and stream infiltration.

Numerous creeks drain Mount Shasta and enter the basin, such as Squaw Valley Creek, Mud Creek, Ash Creek, and Pilgrim Creek. The McCloud River drains the basin to the south. These creeks provide groundwater recharge to the basin.

Deep percolation of applied water is estimated to be 280 acre-feet. These estimates were based on a survey conducted in 1991. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2000. Native land use accounts for about 98% of the basin. The City of McCloud is on the western basin boundary but does not lie entirely within the basin. The population of McCloud (as of 2000) is about 1,300. Table 4-79 provides details of the land uses within the basin.

Table 4-79. Land Use in the McCloud Area Groundwater Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	77	0.36
Subtotal	77	0.36
Urban		
Commercial	42	0.19
Industrial	143	0.67
Urban Landscape	74	0.35
Urban Residential	118	0.55
Vacant	45	0.21
Subtotal	422	1.98
Native		
Native Vegetation	20,835	97.66
Subtotal	20,835	97.66
Total	**21,334**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Siskiyou County adopted a groundwater management ordinance in 1998. The City of McCloud is the only large town (population 1,300) in the basin; it is located on the western basin boundary. The McCloud CSD is the only public water agency within the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

There is no groundwater quality information available for the McCloud Area Basin.

Meadow Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Meadow Valley Groundwater Basin is 9 square miles (5,730 acres) in size and is located in Plumas County. The following description of the hydrogeology in the Meadow Valley Basin is taken from DWR Bulletin 118 (2004).

The basin lies within the Melones Fault Zone of the Sierra Nevada Mountain Range. It is bounded on the west by Mesozoic ultrabasic intrusive rocks, to the north and south by Pliocene pyroclastic rocks, and to the east by ultrabasic intrusive rocks and Paleozoic marine sediments.

Hydrogeologic information was not available from DWR for the water-bearing formations, groundwater level trends, and groundwater storage in the basin. Based on a 1997 DWR survey of land use and sources of water, groundwater extraction for municipal and industrial uses in the Meadow Valley Basin is estimated to be 27 acre-feet. Deep percolation of applied water is estimated to be 60 acre-feet.

The total depth of domestic wells (based on 151 well completion reports) in the basin ranged from 50 to 310 feet, with an average of 125 feet. There is no available data on well yields.

Major Sources of Recharge

The major source of groundwater recharge is precipitation, which ranges from 47 to 53 inches per year, increasing to the southwest (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 5% of the basin, urban land use accounts for about 6% of the basin, and native land accounts for almost 90% of the basin. Table 4-80 provides details on the distribution of land use throughout the Meadow Valley Basin.

Table 4-80. Land Use in the Meadow Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	274	4.78
Subtotal	274	4.78

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Commercial	18	0.31
Urban Landscape	3	0.05
Urban Residential	303	5.28
Subtotal	323	5.63
Native		
Native Vegetation	5,132	89.49
Water	5	0.10
Subtotal	5,138	89.58
Total	**5,735**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for the Meadow Valley Basin. There are no public or private water agencies within the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater samples from one well were analyzed for primary inorganics, radiologicals, nitrates, and secondary inorganics as required under CDPH Title 22 program from 1994 to 2000. There were no detections of these constituents above the MCLs in the well sampled.

Middle Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Middle Creek Groundwater Basin is 1 square mile in size and is located in Lake County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Middle Creek Groundwater Basin is a north-trending basin located west of Pitney Ridge and east of Middle Mountain. The basin consists of Quaternary alluvium and is likely in hydraulic continuity with the Upper Lake Groundwater Basin. Faulting may extend the length of the western boundary. The basin is bounded to the north and east by the Franciscan Formation. Much of the western portion of the basin is bounded by Lower Cretaceous marine deposits.

According to DWR (2004), hydrogeologic information is not available for the water-bearing formations, groundwater level trends, or groundwater storage.

Well completion reports in the basin showed a yield for 1 municipal/irrigation well of 75 gal/min. The average total depth of domestic wells (31 wells reported) is 108 feet, with a range from 31 to 250 feet. The average total depth of municipal/irrigation wells (3 wells reported) is 70 feet, with a range from 54 to 100 feet (DWR 2004).

According to a 1995 DWR survey of land use and sources of water, groundwater extraction for agricultural use is estimated to be 28 acre-feet.

Major Sources of Recharge

Annual precipitation is the major source of recharge and ranges from 43 to 45- inches, increasing to the north. Deep percolation of applied water is estimated to be 6 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 5% of the basin, urban land use accounts for about 4% of the basin, and native land use accounts for about 91% of the basin. Table 4-81 provides details on the distribution of land use throughout the Middle Creek Basin.

Table 4-81. Land Use in the Middle Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	18	2.53
Pasture	18	2.51
Semiagricultural and Incidental	1	0.15
Subtotal	37	5.19
Urban		
Commercial	25	3.61
Industrial	1	0.12
Urban Residential	1	0.12
Subtotal	27	3.85
Native		
Barren and Wasteland	140	19.84
Native Vegetation	502	71.12
Subtotal	641	90.96
Total	**705**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

The CDPH monitors one well in the Middle Creek Basin for miscellaneous water quality parameters but there is no available groundwater quality data.

Middle Fork Feather River Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Middle Fork Feather River Groundwater Basin is 7 square miles (4,340 acres) in size and is located in Plumas County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Middle Fork Feather River Groundwater Basin consists of Quaternary lake and alluvial deposits. The basin is located within a region of northwest trending faults. A fault forms a basin boundary to the east. The basin is bounded to the north and south by Pliocene and Miocene volcanic rocks and to the east and west by Paleozoic marine deposits. The alluvial deposits in the basin are largely located along the North Fork Feather River, which drains the basin to the southwest.

Hydrogeologic information was not available from DWR for the water-bearing formations, groundwater level trends, and groundwater storage in the Middle Fork Feather River Basin.

Based on a 1997 DWR survey of land use and water sources, groundwater extraction for municipal/industrial use is estimated to be 4 acre-feet.

Total depth of domestic wells in the basin ranges from 23 feet to 400 feet, with an average of 150 feet. There is no known data on well yields.

Major Sources of Recharge

Precipitation is the primary source of recharge with annual precipitation ranging from 39 to 47-inches, increasing to the west. Deep percolation of applied water is estimated to be 34 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 4% of the basin, urban land use accounts for about 2% of the basin, and native land use accounts for about 94% of the basin. Table 4-82 provides details on the distribution of land use throughout the Middle Fork Feather River Basin.

Table 4-82. Land Use in the Middle Fork Feather River Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	161	3.70
Semiagricultural and Incidental	7	0.15
Subtotal	167	3.86
Urban		
Commercial	82	1.88
Industrial	13	0.30
Urban Landscape	3	0.06
Urban Residential	4	0.10
Subtotal	102	2.34
Native		
Native Vegetation	4,027	92.77
Water	45	1.04
Subtotal	4,072	93.80
Total	**4,341**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for the basin. There are no known public or private water agencies in the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater samples were analyzed for primary inorganics, nitrates, and secondary inorganics as required under CDPH Title 22 program from 1994 to 2000. Sampling results of these constituents were not above the MCLs. (DWR 2004.)

Mohawk Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Mohawk Valley Groundwater Basin encompasses 30 square miles and is located in Plumas and Sierra Counties. The following description of the hydrogeology in the Mohawk Valley Basin is taken from DWR Bulletin 118 (2004).

The Mohawk Valley Groundwater Basin lies within an elongated valley occupying a portion of a long, narrow graben. The graben is bounded on the southwest side by the Mohawk Valley fault. The east side of the valley is bounded by a group of northwest trending faults that branch from the Mohawk Valley fault near Gattley. The floor of the valley consists of a narrow strip of nearly flat alluvial material overlying lake sediments. Lake sediments also underlie the upland areas of the valley. Depth to bedrock is estimated to range from 1,500 to 3,000 feet. The basin is bounded to the northeast by Pliocene volcanic rocks of Penman Peak, to the east by Miocene volcanic rocks of Beckwourth Peak, and to the west and southwest by Paleozoic metavolcanic rocks and Mesozoic granitic rocks of the Sierra Nevada. Sulphur Creek drains the southern half of the valley and enters Middle Fork Feather River near the midpoint of the valley and flows northwesterly.

The primary water-bearing formations in the basin are Holocene sedimentary deposits and Pleistocene lake and near-shore deposits. Holocene sedimentary deposits include alluvial fans and intermediate alluvium. Alluvial fans consist of unconsolidated gravel, sand, and silt with minor clay lenses. Thickness of the deposits ranges to 200 feet. The fan deposits coalesce or interfinger with lake and alluvial deposits. Specific yield ranges from 8 to 17%.

Intermediate alluvium consists of unconsolidated silt and sand with lenses of clay and gravel. Specific yield is estimated to range from 5 to 25%. This unit is limited in extent. The deposits are up to 50 feet in thickness and yield moderate amounts of groundwater.

Lake and near-shore deposits underlie the majority of the valley and range in thickness to over 2,000 feet. These deposits consist of slightly consolidated, bedded sand, silt, and diatomaceous clay. The sand beds usually yield large quantities of confined groundwater. The near-shore deposits are composed of moderately permeable sand and gravel and, where saturated, yield moderate amounts of groundwater. Specific yield ranges from 1 to 25%.

Storage capacity for the basin is estimated to be 90,000 acre-feet based on a specific yield of 5% for a depth interval of zero to 200 feet.

Based on a 1997 DWR survey of land use and sources of water, groundwater extraction for municipal and industrial uses is estimated to be 130 acre-feet.

Major Sources of Recharge

Precipitation is the primary source of recharge and annually ranges from 27 to 39 inches in the valley and ranges to 51 inches in the upland areas. Deep percolation of applied water is estimated to be 330 acre-feet. (DWR 2004.)

Land Uses

Land use surveys were conducted within the basin by DWR in 1997. Agricultural and urban land use each account for about 7% of the basin, and native land use accounts for over 85% of the basin. Table 4-83 provides details on the distribution of land use throughout the Mohawk Valley Basin.

Table 4-83. Land Use in the Mohawk Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	1,337	7.04
Semiagricultural and Incidental	4	0.02
Subtotal	1,341	7.07
Urban		
Commercial	98	0.52
Urban Landscape	515	2.71
Urban Residential	809	4.26
Subtotal	1,422	7.49
Native		
Native Vegetation	16,122	84.93
Water	99	0.52
Subtotal	16,220	85.45
Total	**18,983**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications pertaining to the Mohawk Valley Basin. Public Water agencies within the basin include Plumas Eureka Community Services District and CLIO PUD.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium-magnesium bicarbonate and sodium bicarbonate are the predominant groundwater types in the basin. TDS ranges from 210 to 285 mg/L, averaging 248 mg/L. Groundwater in the basin has locally high iron, manganese, ammonia, phosphorus, ASAR and boron levels. (DWR 2004.)

Groundwater sampling performed under the requirements of the CDPH Title 22 program from 1994 through 2000 tested for primary and secondary inorganics, radiologicals, nitrates, pesticides, VOCs, and SVOCs. Five wells of 11 sampled for secondary inorganics showed concentrations above the MCLs. Concentrations above the MCL for the other constituents were not detected (DWR 2004).

Mountain Meadows Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Mountain Meadows Valley Groundwater Basin is located to the northeast of Lake Almanor. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004). The basin consists of Quaternary alluvium that encircles Mountain Meadow Reservoir. The basin is bounded to northeast by Jurassic to Triassic metavolcanic rocks and Tertiary non-marine sediments. The basin is bounded to the southeast by Miocene volcanic rocks and to the northwest by Pleistocene basalt. The area of the subbasin is 8,150 acres (13 square miles) and is located in Lassen County.

There is no available information about the hydrogeology of Mountain Meadows Valley Basin.

DWR estimated the groundwater extraction for the Mountain Meadows Valley Basin from a 1997 survey. The survey included land use and sources of water. Groundwater extraction for municipal and industrial uses was estimated to be 7 acre-feet annually.

Major Sources of Recharge

Recharge to the basin is from precipitation (18 inches/year), irrigation infiltration, and stream infiltration. Annual precipitation in the basin ranges from 35 to 39 inches. Deep percolation of applied water is estimated to be 350 acre-feet per year (DWR 2004). Streams in the basin are Roberts Creek, Deerheart Creek, Mountain Meadows Creek, and Greenville Creek.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 46% and undeveloped land accounts for about 54% of the basin. Table 4-84 provides details of the land uses within the basin.

Table 4-84. Land Use in the Mountain Meadows Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	3,740	45.89
Subtotal	3,740	45.89
Urban		
Industrial	10	0.12
Subtotal	10	0.12
Native		
Riparian	1,630	20.00
Native Vegetation	2,660	32.64
Water	110	1.35

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	4,400	53.99
Total	**8,150**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lassen County enacted a groundwater ordinance in 1999 that requires a permit for groundwater exported from the county. There are no known groundwater management plans or basin adjudications. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

North Fork Battle Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The North Fork Battle Creek basin is bounded to the north by Pliocene volcanic rock and on all other sides by Pleistocene volcanic basalt (Gay 1960). The basin consists of several east-west trending courses of alluvium located along North Fork Battle Creek and Bailey Creek. The areal extent of the basin is 12,760 acres (20 square miles) and is located in eastern Shasta County. (DWR 2004.)

The following description of the hydrogeology in the North Fork Battle Creek basin is taken from DWR Bulletin 118 (DWR 2004). Water-bearing formations in the basin include the Quaternary alluvium and underlying volcanic rocks. Driller reports for wells located in the area of Viola (along the eastern basin boundary) show uniform stratification of alluvium and volcanic rocks. The reports indicate that alluvium is approximately 32 feet thick overlying a succession of volcanic rocks (DWR 1984). The volcanic rocks are composed of two 10–40-foot thick flows that are separated by a 40–80-foot section of sand, gravel, ash, and cinders. DWR (1984) indicates that the interbedded sand-gravel-ash-cinder strata are the primary groundwater source in the area. DWR (1984) reports that groundwater in the area of Viola has a seasonal fluctuation of 1 foot with the lowest elevations occurring during periods of maximum evapotranspiration.

DWR (2004) estimated annual groundwater extraction for municipal and industrial use to be 190 acre-feet.

Major Sources of Recharge

Recharge to the principal aquifer is mostly by infiltration of streamflows at the margins of the subbasin. Other sources of recharge are infiltration of applied water and direct infiltration of precipitation (43-49 inches/yr) into the alluvium. Inflow via deep percolation of applied water is estimated to be 220 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1999. North Fork Battle Creek basin contains 90% native land, 6% agricultural land, and 4% urban land. Table 4-85 provides details of the land uses within the basin.

Table 4-85. Land Use in the North Fork Battle Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	751	5.89
Subtotal	751	5.89
Urban		
Urban	6	0.05
Commercial	49	0.39
Urban Residential	426	3.34
Subtotal	482	3.78
Native		
Riparian	33	0.26
Native Vegetation	11,458	89.78
Water	38	0.29
Subtotal	11,529	90.34
Total	**12,762**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. No water agencies are involved with the management of North Fork Battle Creek basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

North Fork Cache Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of the North Fork Cache Creek Groundwater Basin is 5 square miles, located in Lake County. The following description of the North Fork Cache Creek Basin is taken from DWR Bulletin 118 (2004).

The North Fork Cache Creek Groundwater Basin is a north-south trending basin consisting of Quaternary alluvium and stream terrace deposits. The basin is bounded by Mesozoic ultrabasic intrusive rocks in the north. Other sides of the basin are bounded by Franciscan Formation metasediments and Franciscan volcanic and metavolcanic rocks. The valley is drained to the south by North Fork Cache Creek.

According to DWR (2004), hydrogeologic information was not available for the water-bearing formations, groundwater level trends, or storage in the basin.

Major Sources of Recharge

The primary source of recharge is precipitation which ranges from 23 to 25 inches per year, increasing to the south.

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Native land use accounts for 100% of the basin. Table 4-86 provides details on the distribution of land use throughout the North Fork Cache Creek Basin.

Table 4-86. Land Use in the North Fork Cache Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Barren and Wasteland	545	15.69
Native Vegetation	107	3.08
Water	2,824	81.23
Total	**3,477**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). There are no public or private water agencies within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Pope Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The areal extent of the Pope Valley Basin aquifer system is 11 square miles and is located in Napa County. The following description of the hydrogeology is taken from DWR Bulletin 118 (2004).

The Pope Valley groundwater basin occupies a northwest trending structural depression in the central Coast Ranges, approximately 5 miles east of Lake Berryessa. The Pope Valley is approximately 9 miles in length from its northwestern boundary near the town of Aetna Springs to its southeastern margin near the confluence of Maxwell and Hardin Creeks. The basin ranges in width, up to 2 miles. Mountains of the Coast Ranges surround the Pope Valley Basin on all sides. The boundary between the water-bearing and nonwater- bearing materials roughly coincides with the edge of the valley floor. Pope and Maxwell Creeks drain the Pope Valley groundwater basin.

The Quaternary alluvium within the Pope Valley groundwater basin is considered the principal water bearing deposit.

Historically, stream development has been limited to small creeks. Since large stream flows were lacking, accumulations of alluvium seem to have been restricted to the range of 25 feet to 30 feet.

The alluvial material is principally composed of silty to clayey sands and gravels. With an assumed specific yield of 3% most wells yield less than 100 gpm.

Small outcrops of the Sonoma volcanics of Pliocene age occur in the vicinity of Aetna Springs. They are considered to be water bearing but their limited distribution restricts the quantity of groundwater that can be extracted from them to insignificant proportions.

Bedrock beneath the Pope Valley groundwater basin is comprised predominantly of Lower Cretaceous marine sedimentary rocks, which is also found cropping out in the surrounding hills.

According to DWR (2004), there is no published information found that is indicative of groundwater level trends, quantity of groundwater in storage, or groundwater extraction for the Pope Valley groundwater basin. Groundwater storage capacity for the Pope Valley groundwater basin is estimated to contain 7,000 acre-feet of water.

The average total depth of domestic wells in the Pope Valley Basin is 169 feet, with a range from 21 to 600 feet. The average total depth of municipal/irrigation wells is 194 feet, with a range from 60 to 300 feet (DWR 2004).

Major Sources of Recharge

Natural recharge occurs from infiltration of precipitation that falls on the basin floor and in the upland areas within the drainage basin of the valley. The annual precipitation ranges from less than 36 inches in the southeast to more than 40 inches in the northwest (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1999. Agricultural land use accounts for about 32% of the basin, urban land use accounts for about 1% of the basin, and undeveloped land accounts for almost 68% of the basin. Table 4-87 provides details on the distribution of land use throughout the Pope Valley Basin.

Table 4-87. Land Use in the Pope Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	16	0.23
Grain and Hay	197	2.74
Idle	226	3.15
Rice	3	0.04
Semiagricultural and Incidental	29	0.41
Vineyards	1,796	25.01
Subtotal	2,268	31.58
Urban		
Urban—unclassified	5	0.06
Commercial	12	0.16
Urban Landscape	34	0.47
Urban Residential	4	0.06
Vacant	9	0.12
Subtotal	63	0.88
Native		
Riparian	9	0.13
Native Vegetation	4,583	63.80
Water	259	3.60
Subtotal	4,851	67.54
Total	**7,182**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Napa County Flood Control and Water Conservation District is a public water agency within the Pope Valley Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

According to DWR (2004) there is no published data available to characterize the groundwater quality of the Pope Valley groundwater basin. The CDPH monitors 1 well in the basin for Title 22 water quality parameters.

Redding Basin—Introduction

The Redding Basin covers about 510 square miles in the northern part of the Central Valley of California and is surrounded by the Cascade Range, Klamath Mountains, and Coast Ranges. It is separated from the main part of the valley by the Red Bluff Arch, a subsurface geologic structure (Pierce 1983). The Basin is located in Tehama and Shasta Counties and contains six subbasins: Bowman, Rosewood, Anderson, Enterprise, Millville, and South Battle Creek.

Major Sources of Recharge

Recharge to the principal aquifer is mostly by subsurface inflow, infiltration of streamflows at the margins of the subbasin, and infiltration of precipitation and irrigation water. Groundwater movement is generally from the periphery of the basin towards the Sacramento River and then southward, where at the Red Bluff Arch, the water in the sedimentary rocks of Tertiary and Quaternary age is probably discharging into the Sacramento River (Pierce 1983). Therefore, subsurface flow enters the subbasin from the west, and discharges to the east. The major sources of streamflow infiltration are Cottonwood Creek and Dry Creek. Annual precipitation ranges from 23 to 27 inches/yr. The average specific yield for the Redding basin reported to be 8.5%. Storage capacity for the entire Redding basin, assuming and average aquifer thickness of 200 feet, is 5.5 maf (Pierce 1983). Specific yield data for the subbasins is not available to estimate storage capacity for the individual subbasins.

Water Quality

Groundwater in the Redding Basin is characterized as magnesium-calcium bicarbonate and calcium-magnesium bicarbonate type waters. TDS ranges from 70 to 360 mg/L (DWR 2004). Groundwater quality problems include localized high boron concentrations. There is a potential to induce the saline water in the Chico Formation to move upward if pumpage from the Tuscan and Tehama Formations is increased significantly (Pierce 1983). Table 4-88 summarizes the results from Pierce (1983).

Table 4-88. Concentrations of Constituents of Concern Detected in the Redding Basin in 1979

Constituent Type	Constituent of Concern	Concentration ranges	Standards
Nutrients	Nitrate as N	0–10 mg/L, median is 0.59 mg/L	10 mg/L
Salt—primarily as electrical conductivity and total dissolved solids.	Dissolved Solids	95–424 mg/L, median is 166 mg/L	500 mg/L (SMCL)
Trace elements	Arsenic	1–48 µg/L, median 1 µg/L	10 µg/L (MCL as of January 23, 2006)
	Barium	10–100 µg/L, median 30 µg/L	2,000 µg/L (MCL)
	Cadmium	1–2 µg/L, median 1 µg/L	5 µg/L (MCL)
	Chromium	0–10 µg/L, median 0 µg/L	100 µg/L (MCL)
	Chloride	0–140 mg/L, median 3 mg/L	250 mg/L (SMCL)
	Copper	0–14 µg/L, median 1 µg/L	1,000 µg/L (SMCL)
	Fluoride	0–0.3 mg/L, median 0.1 µg/L	4 mg/L (MCL)
	Iron Fe	10–40 µg/L, median 10 µg/L	300 µg/L (SMCL)
	Lead	0–2 µg/L, median 0 µg/L	15 µg/L (MCL)
	Manganese	1–50 µg/L, median 3 µg/L	50 µg/L (SMCL)
	Mercury	0–0.1 µg/L	2 µg/L (MCL)
	Selenium	0–1 µg/L, median 0 µg/L	50 µg/L (MCL)
	Silver	0	0.10 mg/L (SMCL)
	Sulfate	0–170 mg/L, median 3 µg/L	250 mg/L (SMCL)

Notes:
MCL = Maximum Contaminant Level set by EPA (2005).
µg/L = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
Source: Pierce 1983.

Groundwater quality samples were also collected by the USGS in the area surrounding Cottonwood Creek during October 1982 and May 1983 (Fogelman and Evenson 1984). Cottonwood Creek borders Bowman subbasin on the north. Groundwater quality in the Cottonwood Creek area at that time was considered good to excellent with respect to recommended standards. Chemical quality varied little both spatially and seasonally. Groundwater levels were higher in the spring and lower in the autumn, coinciding with precipitation patterns.

One well had high nitrate (as nitrogen) concentrations (12 mg/L during October 1982 and 9.2 mg/L during May 1983). The EPA primary drinking-water limit for nitrate (as nitrogen) is 10 mg/L. This well was a shallow domestic well located at a farmhouse surrounded by pasture. The shallow well depth, shallow water level, and locale of this well lead to the conclusion that the nitrate problem is probably a result of surface contamination through the well borehole.

Water samples from a test well drilled by the Corps exceeded the EPA primary drinking-water limit for arsenic at two of the three depth intervals sampled. Water samples from 246 feet had an arsenic concentration of 0.066 mg/L, and samples from 176 feet had an arsenic concentration of 0.06 mg/L.

Arsenic can be acutely or chronically toxic to humans and plants. The EPA has established 0.01 mg/L as the primary drinking water standard (as of 1/23/06).

Water from two wells exceeded the 0.05-mg/L secondary standard for manganese, with concentrations of 0.066 and 0.13 mg/L. Manganese is objectionable in public water supplies because it affects taste, stains plumbing fixtures, spots laundered clothes, and causes accumulation of oxide deposits in distribution systems.

One well was sampled at three intervals during October 25–26, 1982, for trace metals as well as the standard chemical analyses used in the semiannual groundwater samples. The sample depths were 246 feet, 176 feet, and 104 feet. These samples show that concentrations of calcium, magnesium, sulfate, manganese, cadmium, molybdenum, strontium, and vanadium decrease with increasing depth, and dissolved solids, sodium, alkalinity, chloride, arsenic, boron, lead, lithium, and zinc concentrations increase with increasing depth.

The DPR verified detections of five compounds in Shasta County between 1985 and 2003. There were 2 detections total: 1 detection of ACET and 1 detection of DACT. Verified detections are those that are found at more than one sampling date. These groundwater contaminants were the result of legal, agricultural uses. Access for specific locations for these water quality results was unavailable.

Bowman Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Bowman subbasin is bounded on the west by the Coast Ranges; on the north by Salt, Dry, and Cottonwood Creeks; on the east by the Sacramento River; and on the south by the Red Bluff Arch. The Red Bluff Arch is defined as the hydrologic divide between the drainages of Cottonwood Creek and Hooker Creek to the north and the drainages of Blue Tent Creek, Dibble Creek, and Reeds Creek to the south. The subbasin is 78,500 acres (123 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Bowman subbasin is taken from DWR Bulletin 118 (DWR 2004). The subbasin aquifer system consists of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include Pliocene Tehama and Tuscan formations.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene time. They are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. Modesto Formation deposits are observed along parts of Cottonwood Creek and Hooker Creek and along the Sacramento River. Riverbank Formation deposits are observed along all major creeks. The thickness ranges up to 50 feet. These deposits are moderately to highly permeable and yield limited domestic water supplies.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges and is the principal water-bearing formation in the subbasin. The formation is exposed over approximately 80% of the subbasin surface area. The thickness varies from 4,000 feet to the north to approximately 3,800 feet to the south along Interstate Highway 5. The thickness of the deposit thins to the west from Cottonwood and reaches a thickness of 2,500 feet at the Sacramento River. The permeability of the formation is moderate to high with yields of 100–1,000 gpm.

The Pliocene Tuscan Formation is found interfingered with the Tehama Formation south of Cottonwood Creek. The overlapping thickness may reach up to 2,500 feet towards the Red Bluff Arch. The Tuscan Formation is the principal water-bearing formation at the eastern extents of the subbasin. The formation consists of volcanic gravel and tuff breccia, fine- to coarse-grained volcanic sandstone, conglomerate, tuff, tuffaceous silt and clay predominantly derived from andesitic and basaltic source rocks. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is the oldest water-bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates the deposit in the eastern and northern parts of mapped unit. Unit C consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The unit has limited areal extents and may not occur within the Redding Basin. Permeability is moderate to high with yields of 100–1,000 gpm except for beds of tuff-breccia, which are essentially impermeable.

Long-term groundwater level data indicate a slight decline in groundwater levels associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Some wells increased in levels beyond the pre-drought conditions of the 1970s during the wet season of the early 1980s. Generally, the seasonal fluctuation is approximately 5- feet for normal and dry years. Overall, there do not appear to be any increasing or decreasing trends in groundwater levels.

DWR (2004) estimated annual groundwater extraction for the subbasin for agricultural use at 350 acre-feet. Municipal and industrial use is approximately 9 acre-feet. Inflow via deep percolation of applied water is estimated to be 1,500 acre-feet.

Major Sources of Recharge

Recharge to the principal aquifer is mostly by infiltration of streamflows at the margins of the subbasin. (Pierce 1983). Infiltration of applied water and streamflows, and direct infiltration of precipitation are the main sources of recharge into the alluvium. (DWR 2004.)

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 3% of the subbasin, urban land use accounts for about 3% of the subbasin, and native land accounts for about 94% of the subbasin. Table 4-89 provides details of the land uses within the subbasin.

Table 4-89. Land Use in the Bowman Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	660	0.80
Field Crops	20	0.03
Grain and Hay	80	0.10
Pasture	1,710	2.20
Truck, Nursery, and Berry Crops	10	0.01
Idle	160	0.20
Semiagricultural and Incidental	60	0.10
Subtotal	2,700	3.40
Urban		
Urban Landscape	30	0.04
Urban Residential	1,840	2.30
Commercial	50	0.10
Industrial	50	0.10
Vacant	270	0.30
Subtotal	2,240	2.90
Native		
Native Vegetation	71,800	91.40
Barren and Wasteland	660	0.80
Riparian	300	0.40
Water	850	1.10
Subtotal	73,610	93.70
Total	**78,550**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Bowman groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Tehama County Flood Control and Water Conservation District, Anderson-Cottonwood ID, and Rio Alto Water District.

Tehama County adopted a groundwater ordinance in 1994. Key issues addressed in the ordinance are: mining groundwater for export, off-parcel groundwater use, and well pumping restrictions. In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. Tehama adopted a countywide groundwater management plan pursuant to AB 3030 in 1996. County ordinance 1617 prohibits extraction of groundwater for export outside the county.

No urban areas are located within the subbasin. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Rosewood Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Rosewood subbasin is bounded on the west and northwest by the Coast Ranges, on the north by North Fork Cottonwood Creek, and on the southeast by Salt Creek, Dry Creek, and Cottonwood Creek. The subbasin is 46,500 acres (73 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Rosewood subbasin is taken from DWR Bulletin 118 (DWR 2004). The Rosewood subbasin aquifer system west of the Sacramento River is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include the Pliocene Tehama Formation.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank Formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene time. They are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. Modesto Formation deposits are observed along parts of Cottonwood Creek. Riverbank Formation deposits are observed along all major creeks. The thickness ranges up to 50 feet. The deposits are moderately to highly permeable and yield limited domestic water supplies.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges. The formation is the principal water-bearing formation in the subbasin and is exposed over approximately 80% of the subbasin surface area. Thickness of the deposits is unknown but may reach up to 500 feet, thinning to the west where the Great Valley Sequence daylights at the subbasin boundary. The permeability of the formation is moderate to high with yields of 100–1,000 gpm.

Long-term groundwater level data indicate a slight decline in groundwater levels associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Generally, groundwater levels have a seasonal fluctuation of approximately 5–10 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels.

Estimated groundwater extraction for agricultural use to be 680 acre-feet. Municipal and industrial use is estimated to be approximately 990 acre-feet. (DWR 2004.)

Major Sources of Recharge

Cottonwood and Dry Creeks recharge Rosewood subbasin on the north and southeast. Annual precipitation ranges from 23 to 27 inches per year. Deep percolation of applied water is estimated to be 1,200 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 4% of the subbasin, urban land use accounts for less than 1% of the subbasin, and native land accounts for about 96% of the subbasin. Table 4-90 provides details of the land uses within the subbasin.

Table 4-90. Land Use in the Rosewood Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	80	0.20
Field Crops	10	0.02
Grain and Hay	350	0.80
Pasture	1,220	2.60
Truck, Nursery, and Berry Crops	30	0.10
Vineyards	10	0.02
Idle	130	0.30
Semiagricultural and Incidental	60	0.10
Subtotal	1,890	4.10
Urban		
Urban Residential	170	0.40
Commercial	10	0.02
Vacant	20	0.04
Subtotal	200	0.40
Native		
Native Vegetation	43,200	92.80
Barren and Wasteland	800	1.70
Riparian	260	0.60
Water	190	0.40
Subtotal	44,450	95.50
Total	**46,540**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Rosewood groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Anderson-Cottonwood ID, and Igo-Ono Community Service District. Tehama County adopted a groundwater ordinance in 1994. Key issues addressed in the ordinance are: mining groundwater for export, off-parcel groundwater use, and well pumping restrictions. In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. Tehama adopted a countywide groundwater management plan pursuant to AB 3030 in 1996. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county.

No urban areas are located within the subbasin.

This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Anderson Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Anderson subbasin is bounded on the west and northwest by bedrock of the Klamath Mountains, on the east by the Sacramento River, and on the south by Cottonwood Creek. The subbasin is 96,950 acres (151 square miles) in size and is located in Shasta County.

The following description of the hydrogeology in the Anderson subbasin is taken from DWR Bulletin 118 (DWR 2004). The Anderson subbasin aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include Pliocene Tehama and Tuscan Formations. The Tehama Formation interfingers with the Tuscan Formation in the region between Interstate Highway 5 and the Sacramento River north of the city of Red Bluff.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene time. They are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. Modesto Formation deposits are observed along parts of Cottonwood Creek, Dry Creek, and along the Sacramento River. Riverbank terrace deposits are observed along all major creeks. The thickness ranges up to 50 feet. These deposits are moderately to highly permeable and yield limited domestic water supplies.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges and is the principal water-bearing formation west of the Sacramento River. The formation is exposed over approximately 60 to 70% of the subbasin surface area. Thickness of the formation ranges from 1,000 to 4,000 feet from the northern subbasin boundary at the Sacramento River to Cottonwood Creek in the vicinity of Interstate Highway 5. Much of the deposit west of Anderson has a uniform thickness of approximately 500 feet which thins to the western subbasin boundary where the Great Valley Sequence daylights. The permeability of the formation is moderate to high with yields of 100–1,000 gpm.

The Pliocene Tuscan Formation is thought to interfinger with the Tehama Formation between the Sacramento River to the east and Interstate 5. The formation consists of volcanic gravel and tuff-breccia, fine- to coarse-grained volcanic sandstone, conglomerate, tuff, tuffaceous silt and clay predominantly derived from andesitic and basaltic source rocks. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is the oldest water-bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates the deposit in the eastern and northern parts of mapped unit. Unit C consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The unit has limited areal extents and may not occur within the Redding Basin. Permeability is moderate to high with yields of 100–1,000 gpm except for beds of tuff-breccia that are essentially impermeable.

Long-term groundwater level data indicates a slight decline in levels associated with the 1976–1977 and 1987–1994 droughts, followed by a gradual recovery to pre-drought conditions of the early 1970s and 1980s. Generally, the seasonal fluctuation ranges from 1 to 10 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in groundwater levels.

DWR (2004) estimated annual groundwater extraction for the subbasin for agricultural use at 3,000 acre-feet. Municipal and industrial use is approximately 20,000 acre-feet.

Major Sources of Recharge

Recharge to the subbasin is mostly from infiltration of streamflows. Infiltration of applied water and streamflows, and direct infiltration of precipitation are the main sources of recharge into the alluvium. Deep percolation of applied water is estimated to be 5,700 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 15% of the subbasin, urban land use accounts for about 20% of the subbasin, and native land accounts for about 65% of the subbasin. Table 4-91 provides details of the land uses within the subbasin.

Table 4-91. Land Use in the Anderson Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	970	1.00

Land Use	Acreage of Land Use	Percent of Land Use
Deciduous Fruits and Nuts	1,300	1.30
Field Crops	340	0.40
Grain and Hay	420	0.40
Pasture	9,080	9.40
Truck, Nursery, and Berry Crops	230	0.20
Idle	1,540	1.60
Semiagricultural and Incidental	270	0.30
Subtotal	14,150	14.60
Urban		
Urban—unclassified	4,920	5.10
Urban Landscape	80	0.10
Urban Residential	11,000	11.30
Commercial	430	0.40
Industrial	2,150	2.20
Vacant	730	0.80
Subtotal	19,130	19.90
Native		
Native Vegetation	58,900	60.70
Barren and Wasteland	1,000	1.00
Riparian	2,260	2.30
Water	1,350	1.40
Subtotal	63,150	65.50
Total	**96,970**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Anderson groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Redding Area Water Committee, Anderson-Cottonwood ID, Clear Creek ID, City of Anderson, Keswick Community Service District, City of Redding, Rio Alto WD, Shasta Community Service District and Shasta County Water Agency, IGO-ONO Community Service District.

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. The cities of Redding and Anderson are urban areas located within the subbasin. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Enterprise Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Enterprise subbasin is bounded on the west and southwest by the Sacramento River, on the north by the Klamath Mountains, and on the east by Little Cow Creek and Cow Creek. The subbasin is 60,900 acres (95 square miles) in size and is located in Shasta County.

The following description of the hydrogeology in the Enterprise subbasin is taken from DWR Bulletin 118 (DWR 2004). The Enterprise subbasin aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene Stream Channel Deposits and terrace deposits of the Modesto and Riverbank Formations. The Tertiary deposits are the Pleistocene Tehama Formation and the Tuscan Formation.

The youngest alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These Holocene stream channel deposits are observed along the entire extents of the western boundary along the Sacramento River. These deposits are also observed along Stillwater Creek extending from the Klamath Mountains to the Sacramento River in the center of the subbasin and along Cow Creek on the eastern side. The thickness ranges to 50 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank Formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene. They are usually found as terrace deposits near the surface along the Sacramento River and tributaries. The thickness ranges to 50 feet. They are moderately to highly permeable and yield limited domestic water supply from perched water tables.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges. Thickness of the formation along the southern boundary ranges from 300 feet at the southwestern extents of the subbasin to 1,000 feet at the confluence of Cow Creek and the Sacramento River. From north to south along Cow Creek, the deposit uniformly increases in thickness from where the Chico Formation daylights near Bella Vista to a depth of 500 feet in the vicinity of Palo Cedro and to a depth of 1,000 feet at the Sacramento River. The permeability is moderate to high, with yields of 100–1,000 gpm. The formation interfingers with the Tuscan Formation along the eastern boundary; however, the extents are unknown.

The Pliocene Tuscan Formation consists of volcanic gravel and tuff-breccia, fine- to coarse-grained volcanic sandstone, conglomerate and tuff, tuffaceous silt and clay predominantly derived from andesitic and basaltic source rocks. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is the oldest water-bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates the deposit in the eastern and northern parts of mapped unit. Unit C consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The unit has limited areal extents and may not occur within the Redding Basin. Permeability is moderate to high with yields of 100–1,000 gpm except for beds of tuff-breccia, which are essentially impermeable.

Long-term *groundwater* level data indicate a gradual decline of approximately 5–10 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a gradual recovery to pre-drought conditions of the early 1970s and 1980s. Evaluation of groundwater level data shows a seasonal fluctuation of approximately 5–10 feet. Overall, there does not appear to be any increasing or decreasing trends in groundwater levels.

DWR (2004) estimated annual groundwater extraction for the subbasin for agricultural use to be 3,000 acre-feet. Municipal and industrial use is approximately 20,000 acre-feet.

Major Sources of Recharge

Recharge to the aquifer is mostly by infiltration of streamflows. Infiltration of applied water and streamflows, and direct infiltration of precipitation are the main sources of recharge into the alluvium. Deep percolation of applied water is estimated to be 3,788 acre-feet (DWR 2004).

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 12% of the subbasin, urban land use accounts for about 34% of the subbasin, and native land accounts for about 54% of the subbasin. Table 4-92 provides details of the land uses within the subbasin.

Table 4-92. Land Use in the Enterprise Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	40	0.10
Deciduous Fruits and Nuts	310	0.50
Field Crops	570	0.90
Grain and Hay	790	1.30
Idle	1,510	2.50
Pasture	3,920	6.40
Semiagriculture and Incidental	180	0.30
Truck, Nursery, and Berry Crops	120	0.20
Subtotal	7,440	12.20
Urban		
Urban—unclassified	2,720	4.50
Commercial	820	1.30
Industrial	240	0.40
Urban Landscape	290	0.50
Urban Residential	15,400	25.30

Land Use	Acreage of Land Use	Percent of Land Use
Vacant	1,410	2.30
Subtotal	20,880	34.30
Native		
Barren and Wasteland	120	0.20
Riparian	760	1.20
Native Vegetation	30,370	49.80
Water	1,380	2.30
Subtotal	32,630	53.50
Total	**60,950**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Enterprise groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Redding Area Water Committee, Bella Vista WD, Shasta Co. Water Agency, Shasta Community Service District. Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Millville Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Millville Subbasin is bounded on the west by Cow Creek, Little Cow Creek, and the Sacramento River; on the north by the Klamath Mountains; on the east by the Cascade Range; and on the south by Battle Creek. The subbasin is 65,300 acres (102 square miles) in size and is located in Shasta County.

The following description of the hydrogeology in the Millville subbasin is taken from DWR Bulletin 118 (DWR 2004). The Millville subbasin aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include the Pliocene Tehama Formation along the Sacramento River and the Tuscan Formation. The Tuscan Formation is the primary water-bearing unit in the subbasin.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These alluvial deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage due to its geomorphic distribution.

The Pleistocene Modesto and Riverbank Formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene. The formations are usually found as terrace deposits near the surface along the Sacramento River and tributaries. The thickness ranges to 50 feet. They are moderately to highly permeable and can yield limited domestic water supplies.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges. The permeability of the formation is moderate to high with yields of 100–1,000 gpm.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers and is the principal water-bearing formation in the subbasin. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates the deposit in the eastern and northern parts of mapped unit. Unit C consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The unit has limited areal extents and may not occur within the Redding Basin. Unit C is the primary surficial deposit within the subbasin. Surficial deposits of Unit B are exposed over 15 to 20% of the subbasin to the north.

Deposits of the Tehama and Tuscan Formations interfinger along the western extents of the subbasin. Deposits of the Chico Formation outcrop in the northern most portion of the subbasin in the vicinity of Little Cow Creek and Cow Creek. Deposits of the Tehama and Tuscan formations begin at the northern extents of the subbasin and increase in thickness to approximately 1,000 feet at the confluence of Cow Creek and the Sacramento River. In the vicinity of Palo Cedro, the thickness of the sediments is approximately 500 feet. The thickness of the deposits decreases to the east and deposits of the Chico Formation between Cow Creek and Oak Run Creek in the northern half of the subbasin show that the Tuscan has been totally eroded in those areas.

Long-term groundwater level data indicate a slight decline of approximately 5 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a gradual recovery in levels to pre-drought conditions of the early 1970s and 1980s. Generally, seasonal fluctuations range from 2 to 8 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trend in groundwater levels.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 4% of the subbasin, urban land use accounts for about 3% of the subbasin, and native land accounts for about 93% of the subbasin. Table 4-93 provides details of the land uses within the subbasin.

Table 4-93. Land Use in Millville Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	150	0.20

Land Use	Acreage of Land Use	Percent of Land Use
Field Crops	220	0.30
Grain and Hay	60	0.10
Pasture	2,170	3.30
Rice	30	0.05
Idle	140	0.20
Semiagricultural and Incidental	80	0.10
Subtotal	2,850	4.40
Urban		
Urban—unclassified	20	0.03
Urban Landscape	20	0.03
Urban Residential	1,700	2.60
Commercial	80	0.10
Industrial	80	0.10
Vacant	10	0.02
Subtotal	1,910	2.90
Native		
Native Vegetation	59,900	91.80
Riparian	80	0.10
Water	510	0.80
Subtotal	60,490	92.70
Total	**65,250**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Millville groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Redding Area Water Committee, Bella Vista WD, Shasta Co. Water Agency, Shasta Community Service District. Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. There are no urban areas located within the subbasin. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

South Battle Creek Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The South Battle Creek subbasin is bounded to the west by the Sacramento River, to the north by Battle Creek, to the east by the Cascade Range, and to the south by the drainage divide along the north rim of Paynes Creek. The subbasin is 33,860 acres (53 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the South Battle Creek subbasin is taken from DWR Bulletin 118 (DWR 2004). The South Battle Creek aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include younger alluvium and the Pleistocene Modesto Formation. The Tertiary deposits include the Tuscan Formation and possibly the Tehama Formation along the Sacramento River. The Tuscan Formation is the primary water-bearing unit in the subbasin. The Tehama Formation interfingers wit the Tuscan Formation in the region between Interstate Highway 5 and the Sacramento River north of the city of Red Bluff. The Tehama Formation may extend beyond the Sacramento River within the subbasin boundary; however, the deposit is not included here as a water-bearing formation.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along the Sacramento River. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable it is not a significant contributor to groundwater usage due to its geomorphic distribution.

The Pleistocene Modesto Formation consists of terrace deposits containing poorly consolidated gravel with some sand and silt. These deposits are found along Inks Creek, Battle Creek, and the Sacramento River. The thickness varies up to 50 feet. The sediments are moderately to highly permeable and yield limited domestic water supplies.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers and is the principal water-bearing formation in the subbasin. Generally, the formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates in the eastern and northern parts of mapped unit. This portion of the formation is approximately 430 feet thick.

Unit C is the primary surficial deposit in the subbasin and consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. The thickness of Unit C exposed in the vicinity of Tuscan Springs and Tuscan Buttes ranges from 165 to 265 feet. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The deposit varies in thickness from 30 to 160 feet. The total thickness of the Tuscan Formation ranges from approximately 750 feet in the northeastern extents of the subbasin to 2,400 feet at the Sacramento River.

Data is not available for groundwater levels for this subbasin.

Estimates of groundwater extraction are based on surveys conducted during 1994 and 1995 by the California Department of Water Resources. Annual groundwater extraction for agricultural uses is estimated to be 1,300 acre-feet. Municipal and Industrial uses are approximately 310 acre-feet (DWR 2004).

Major Sources of Recharge

Recharge to the aquifer is mostly by infiltration of streamflows. Infiltration of applied water and streamflows, and direct infiltration of precipitation are the main sources of recharge into the alluvium. Deep percolation of applied water is estimated to be 860 acre-feet (DWR 2004).

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 7% of the subbasin, urban land use accounts for less than 1% of the subbasin, and native land accounts for about 93% of the subbasin. Table 4-94 provides details of the land uses within the subbasin.

Table 4-94. Land Use within the South Battle Creek Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	10	0.03
Deciduous Fruits and Nuts	880	2.60
Grain and Hay	70	0.20
Pasture	1,120	3.30
Idle	100	0.30
Rice	20	0.06
Semiagricultural and Incidental	10	0.03
Subtotal	2,210	6.50
Urban		
Urban Residential	10	0.03
Industrial	40	0.10
Vacant	30	0.10
Subtotal	80	0.20
Native		
Native Vegetation	30,800	90.90
Barren and Wasteland	90	0.30
Riparian	420	1.20
Water	300	0.90
Subtotal	31,610	93.20
Total	**33,900**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The South Battle Creek groundwater subbasin is within the Shasta-Tehama Watershed. The public agencies operating within the subbasin is the Tehama County Flood Control and Water Conservation District.

In 1994 Tehama County adopted groundwater ordinance 1617. Key issues addressed in the ordinance are: mining groundwater for export, off-parcel groundwater use, and well pumping restrictions. In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. Tehama adopted a countywide groundwater management plan pursuant to AB 3030 in 1996.

No urban areas are located within the subbasin. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. This subbasin falls within the area included in the Sacramento Valley Water Quality.

Rock Prairie Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of Rock Prairie Valley Basin is 9 square miles (5,740 acres) it is located in southeastern Modoc County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Rock Prairie Valley Basin is an alluvial filled valley. It is bounded to the northeast by northwest trending faults. The basin is bounded to the northeast, southeast, and west by Pliocene basalt and to the southwest by Miocene basalt. The valley drains to the northeast. Graven and Bailey Reservoirs are located along the eastern boundary.

No hydrogeologic information was available from DWR for water-bearing formations, groundwater level trends, storage, budget, or groundwater quality.

Major Sources of Recharge

The primary source of recharge is annual precipitation which ranges from 19 to 21 inches (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1997. The entire basin is comprised of native vegetation and water. Table 4-95 provides details on the distribution of land use throughout the Rock Prairie Valley Basin.

Table 4-95. Land Use in the Rock Prairie Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	5,229	91.11
Water	510	8.89
Total	**5,739**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the Modoc County ordinance is the requirement of an export permit for groundwater transferred out of the basin (DWR 2004). California Pines CSD is the sole public water agency in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Round Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Round Valley groundwater basin is located in Modoc County. The area of the basin is 7,270 acres (11 square miles). It is northeast of Big Valley and surrounded entirely by Mountains. The basin is bounded to the northwest by Tertiary basalt of Ryan and Barbar ridges, to the north and northeast by Tertiary pyroclastic rocks of Horsehead Mountain, and to the south and southwest by Tertiary pyroclastic rocks.

Ash Creek enters the valley from the southeast and continues to flow to the southwest entering Big Valley through a narrows in Barber Ridge. The following description of the hydrogeology in the Round Valley Basin is taken from DWR Bulletin 118 (DWR 2004).

The primary water-bearing formations in Round Valley are Holocene sedimentary deposits, Pliocene lava flows, and the Plio-Pleistocene Bieber Formation. The Holocene sedimentary deposits include basin deposits, intermediate alluvium, and alluvial fan deposits. Basin deposits, located predominately in low-lying areas in the southeast central part of the valley, consist of unconsolidated interbedded silt, clay, and organic muck having low permeability. These deposits are not considered a significant water-bearing formation.

Intermediate alluvium, found along the perimeter and the northwest central part of the valley, consists of unconsolidated silt and sand with some clay and gravel. These deposits are generally moderately permeable with gravel zones being highly permeable. Alluvial fan deposits consist of unconsolidated poorly stratified silt, sand, and gravel with some clay lenses. Because the fans occur in only a few small areas, they are not considered a significant source of water. Locally they may yield moderate amounts of water to wells.

The Bieber Formation consists of lake deposited diatomite, clay, silt, sand, and gravel. These interbedded sediments are unconsolidated to semi-consolidated and are moderately permeable. The principal water-bearing zones consist of white pumiceous sand and black volcanic sand, which yield large amounts of water to wells where there is sufficient thickness and continuity.

Pliocene lavas consisting of jointed and fractured basalt occur to the north and south of Round Valley on the surrounding ridges. The lavas are moderately permeable and serve primarily as recharge areas in the uplands. They may contain unconfined and confined zones near the margins of the valley.

Storage capacity for the Round Valley Basin is estimated to be 120,000 acre-feet to a depth of 200 feet (DWR 1963). DWR (1963) also notes that the quantity of useable water in storage is unknown. DWR estimates groundwater extraction for agricultural and municipal/industrial uses to be 400 and 4 acre-feet, respectively. This estimate is based on surveys conducted by the DWR during 1997.

Major Sources of Recharge

Recharge to the basin is from precipitation, irrigation infiltration, and stream infiltration. The average annual precipitation ranges from 15 to 19 inches (DWR 2004). Deep percolation of applied water is estimated by DWR (2004) to be 460 acre-feet. Ash Creek enters the valley from the southeast and continues to flow to the southwest entering Big Valley through a narrows in Barber Ridge. Dutch Flat Creek and Rush Creek also flow through the Round Valley.

Groundwater within the sediments of Round Valley is recharged primarily from the upland recharge areas of Pliocene basalt northwest of Round Valley (DWR 2004). The Turner Creek Formation of Ryan Ridge is a barrier between the Round Valley aquifer and the groundwater moving downslope through Barber Canyon.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Round Valley Basin is 37% Agricultural and 63% undeveloped. Table 4-96 provides details of the land uses within the basin.

Table 4-96. Land Use in the Round Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	430	5.91
Idle	160	2.20
Pasture	2,050	28.20
Semiagricultural and Incidental	50	0.69

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	2,690	37.00
Native		
Native Vegetation	4,510	62.04
Water	70	0.96
Subtotal	4,580	63.00
Total	**7,270**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. Groundwater ordinances generally affect the volume of groundwater that can be pumped and/or exported from the basin. A key element of the Modoc County ordinance requires an export permit for groundwater transferred out of the basin (DWR 2004). The Adin Community Service District is the only public water agency involved with the basin. There are no major urban areas within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Sodium bicarbonate type waters are present in the basin. The concentration of TDS ranges from 141 to 633 mg/L, averaging 260 mg/L. There is no information about groundwater quality problems.

Scotts Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

Scotts Valley Basin is bordered to the east by the shoreline of Clear Lake and bounded on the west and the north by the Jurassic-Cretaceous Franciscan complex of metamorphic and sedimentary rocks that constitute the basement rock in the basin. The basin shares a boundary with the Big Valley Basin to the south and may be hydrologically contiguous. The area of the aquifer system is 11 square miles and is located in Lake County.

The following description of the hydrogeology in the Scotts Valley Basin is taken from DWR Bulletin 118 (2004). The Scotts Valley Basin lies adjacent to the west side of Clear Lake and extends northwesterly along Scotts Creek north to Hidden Lake. The aquifer system in Scotts Valley Basin is composed primarily of Quaternary alluvial and terrace deposits, and Plio-Pleistocene to Pleistocene lake and floodplain deposits. Plio-Pleistocene Cache Formation sediments overlie bedrock.

The channel deposits of Scotts Creek and the uppermost valley deposits in the southern portion of basin are composed of Quaternary alluvium. The active channel of Scotts Creek is underlain by uncemented gravel and sand, with silt and clay lenses. Sands and gravels within the alluvium have moderate to high permeability while the silt and clay lenses have a relatively low permeability. In the southern part of the valley, gravels and clays are interbedded at shallower depths representing portions of former stream channels. Wells extract variable amounts of water from these zones. Wells installed in sand and gravel lenses yield an average of about 230 gpm. Surficial lake deposits of sandy and silty clay are located in the northern portion of the basin. Underlying these deposits is a fairly continuous gravel stratum in which water is under artesian pressure. Groundwater is confined in the northern portion of the valley and is essentially unconfined in the southern portion. The confined aquifer is 3 to 10 feet thick and underlies approximately 2.4 square miles of valley floor at depths ranging from 85 to 105 feet. The unconfined aquifer underlying the southern valley floor varies in thickness from 40 to 70 feet.

The northern part of Scotts Valley is underlain by lake deposits of sandy and silty clay ranging in thickness from 60 to 90 feet. Permeability in the fine-grained lake deposits is low with specific yields ranging from about 3 to 5%.

Terrace deposits lie directly on bedrock or on older lake and floodplain deposits. These deposits are a continuation of terrace deposits as seen in the Western Upland aquifer system of Big Valley Basin to the south. They consist of poorly consolidated clay, silt, and sand, with some gravel lenses. Thickness of the deposits ranges from 50 to 100 feet. These deposits generally have low permeability due to high clay content. Available well records indicate reddish brown clays with little potential for significant water yield.

Pre-terrace sediments that exist in Scotts Valley area are identified as the Cache Formation based on the stratigraphic position and the lithologic similarity to known beds of that formation. The Cache Formation is largely made up of lake deposits; however, some stream deposits and volcanic ash lenses are likely included. The Cache Formation is identified from water well driller reports as a blue clay layer containing some gravel lenses that is several hundred feet thick. Permeability of the Cache Formation is generally low due to its high clay content; however, yields of groundwater extracted from gravel or ash lenses within the Cache Formation may be appreciable.

Evaluation of the groundwater level data shows an average seasonal fluctuation ranging from 5 to 10 feet for normal and dry years for wells located in the vicinity of Scotts Creek and Clear Lake. For wells located closer to the Coast Ranges, the average seasonal fluctuation is approximately 20 to 40 feet for normal and dry years.

Long-term comparison of spring-spring groundwater levels indicates a slight decline in groundwater levels of up to 10 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery in levels to pre-drought conditions of early 1970s and 1980s. Overall there does not appear to be any increasing or decreasing trend in the groundwater levels.

Data indicates that lowering of groundwater levels accompanied by subsidence has occurred in Scotts Valley. Gravel has been extracted to average depths of 4 to 6 feet and up to 10 to 15 feet within Scotts Creek channel. This extraction has apparently resulted in the lowering of the stream channel and adjacent unconfined groundwater levels by about 3–4 feet in the southern portion of the valley.

The average specific yield for the depth interval of 0–100 feet is estimated to be 8% based on review and analysis of well logs. The storage capacity for the basin is estimated to be 5,900 acre-feet based on the above depth interval and estimate of specific yield. The useable storage capacity is estimated to be 4,500 acre-feet. Based on 1995 DWR surveys of land use and sources of water, groundwater extraction for agricultural use is estimated to be 4,200 acre-feet. Groundwater extraction for municipal/industrial uses is estimated to be 520 acre-feet. Deep percolation of applied water is estimated to be 1,000 acre-feet (DWR 2004).

Major Sources of Recharge

Recharge to the confined aquifer takes place in the forebay or unconfined zone in the southern portion of the valley. Percolation from Scotts Creek is the principal source of recharge with minor amounts from precipitation and applied irrigation water. Annual precipitation in the basin ranges from 31 to 35 inches, increasing the northwest. (DWR 2004)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 27% of the basin, urban land use accounts for about 18% of the basin, and native land use accounts for about 55% of the basin. Table 4-97 provides details on the distribution of land use throughout the Scotts Valley Basin.

Table 4-97. Land Use in the Scotts Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	5	0.06
Deciduous Fruits and Nuts	1,231	16.80
Idle	337	4.59
Pasture	313	4.27
Semiagricultural and Incidental	34	0.46
Vineyards	41	0.56
Subtotal	1,960	26.75
Urban		
Commercial	272	3.72
Industrial	1	0.01
Urban Landscape	32	0.44
Urban Residential	933	12.73
Vacant	108	1.48
Subtotal	1,346	18.38
Native		
Riparian	12	0.17
Native Vegetation	3,936	53.72
Water	72	0.99
Subtotal	4,020	54.87
Total	**7,326**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance for Scotts Valley Basin in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). Public water agencies in the basin include County of Lake, City of Lakeport WSA, and Scotts Valley WCD.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater levels in the Scotts Valley Basin are monitored semi-annually by DWR at 3 wells and by Lake County at 6 wells. Miscellaneous water quality parameters are monitored by DWR biennially at one well. CDPH and its cooperators monitor for Title 22 water quality parameters in 9 wells.

Calcium-magnesium bicarbonate is the predominant groundwater type in the Scotts Valley Basin. TDS ranges from 140 to 175-mg/L, averaging 158 mg/L. Iron, manganese, and boron concentrations exceed EPA maximum acceptable concentrations for continuous irrigation for selected wells (DWR 2004). During the sampling period from 1994 to 2000 under the CDPH Title 22 program, there was 1 well out of 7 wells sampled with concentration of primary inorganics detected above the MCL. One well of 9 wells sampled showed nitrate concentrations above the MCL.

Chilcoot Subbasin—Sierra Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the Chilcoot subbasin is taken from DWR Bulletin 118 (2004). The Chilcoot subbasin aquifer is bounded to the north and east by Mesozoic granitic rocks and, to the south, by Tertiary Sierran basalt and pyroclastic rocks and Paleozoic metamorphic rocks. The basin is hydrologically connected to the Sierra Valley Subbasin to the west in the near surface but may be discontinuous at depth due to a bedrock sill. The aquifer system is 12 square miles in size and is located on the eastern side of the Sierra Valley Groundwater Basin in Plumas County.

The Chilcoot Subbasin is an irregularly shaped, complexly faulted valley. The surface drainage is a tributary to Little Last Chance Creek, which drains to the Middle Fork Feather River. The primary water-bearing formations in the Chilcoot Subbasin are the Holocene sedimentary deposits and silt and sand deposits, fractured and faulted Paleozoic to Mesozoic metamorphic and granitic rocks, and Tertiary volcanic rocks.

Holocene sedimentary deposits include alluvial fans and intermediate alluvium. Alluvial fans consist of unconsolidated gravel, sand, and silt with minor clay lenses. These deposits are located at the perimeter of the valley to a thickness of 200 feet and are a major source of confined and unconfined groundwater. The fan deposits coalesce or interfinger with basin, lake, and alluvial deposits. Specific yield ranges from 8 to 17%. The fans also serve as important recharge areas.

Intermediate alluvium consists of unconsolidated silt and sand with lenses of clay and gravel. Specific yield is estimated to range from 5 to 25%. This unit is limited in extent and is found along the margins of the basin. The deposits are up to 50 feet in thickness and yield moderate amounts of groundwater to shallow wells.

Sand and silt deposits are located in the northeast portion of the subbasin. The deposits are generally unconsolidated and have high permeability and porosity. Potentially large quantities of water may be extracted.

Volcanic rocks make up a portion of the bedrock outcrop north of Chilcoot along Frenchman Lake road. These rocks are fractured and faulted and produce between 5 and 10 gpm where wells encounter interconnected openings in the rock.

These rocks form the bedrock base of the subbasin and most of the surrounding mountain uplands. The metamorphic rocks underlie the eastern portion and the granitic rocks the western portion of the subbasin. Major north-south high angle faults form the contacts between these rocks. Several test wells drilled in a proposed subdivision in the area show that where wells encounter sufficient interconnected fractures, wells developed in these rocks can produce up to 20 gpm, but typically only produce 3–5 gpm (DWR 2004).

The estimated groundwater storage in the basin is 7,500,000 acre-feet to a depth of 1,000 feet (DWR 1963). The quantity of water that is useable is unknown. DWR (1973) estimates storage capacity to be between 1,000,000 and 1,800,000 acre-feet for the top 200 feet of sediments based on an estimated specific yield ranging from 5 to 8%. These estimates include the Sierra Valley Subbasin.

Estimates of groundwater extraction for the Chilcoot Subbasin are based on a survey conducted by the DWR during 1997. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 64 and 72 acre-feet respectively.

Major Sources of Recharge

Annual precipitation ranges between 13 and 17 inches, increasing to the south (DWR 2004).

Most of the upland recharge areas are composed of permeable materials occurring along the upper portions of the alluvial fans that border the valley. Recharge to groundwater is primarily by way of infiltration of surface water from the streams that drain the mountains and flow across the fans. A minor amount of recharge may also be derived from some of the Sierran volcanic rocks located south of the valley. Most of these rocks appear to be of fairly low permeability and only small quantities of recharge can be derived from them (DWR 2004). Deep percolation from applied water is estimated to be 400 acre-feet (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for over 25% of the subbasin, urban land use accounts for about 3% of the subbasin, and native land use accounts for about 71% of the subbasin. Table 4-98 provides details on the distribution of land use throughout the Chilcoot subbasin.

Table 4-98. Land Use in the Chilcoot Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	1,899	25.20
Semiagricultural and Incidental	28	0.37
Subtotal	1,927	25.54
Urban		
Industrial	30	0.39
Urban Landscape	5	0.07
Urban Residential	205	2.71
Subtotal	239	3.17
Native		
Native Vegetation	5,379	71.28
Subtotal	5,379	71.28
Total	**7,546**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Loyalton WD is included in this subbasin. Groundwater management is under the Sierra Valley Groundwater Management District (authorized by Senate Bill 1391, enacted in 1980).

This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

DWR monitors groundwater levels at 15 wells semi-annually, and samples for miscellaneous water quality parameters at 15 wells (including subbasin 5-12.01) biennially. CDPH and its cooperators sample for miscellaneous water quality parameters in 8 wells (frequency of sampling not specified) (DWR 2004).

Groundwater in the subbasin is bicarbonate type water with mixed cationic character. TDS concentrations for the Sierra Valley Groundwater Basin range from 110 to 1,620 mg/L, averaging 321 mg/L (DWR 2004).

Sierra Valley Subbasin—Sierra Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Sierra Valley groundwater subbasin is bounded to the north by Miocene pyroclastic rocks of Reconnaissance Peak, to the west by Miocene andesite of Beckwourth Peak, to the south and east by

Tertiary andesite, and to the east by Mesozoic granitic rocks. The aquifer system is 184 square miles in size and is located in eastern Plumas and Sierra Counties.

The following description of the hydrogeology in the Sierra Valley subbasin is taken from DWR Bulletin 118 (2004). Sierra Valley is an irregularly shaped, complexly faulted valley. The Middle Fork Feather River heads in Sierra Valley and is formed by the confluence of several streams draining the surrounding mountains. Most of the smaller tributaries flow north and northwest to join the Middle Fork Feather before it exits the valley at the northwest corner of the basin.

The primary water-bearing formations in Sierra Valley are Holocene sedimentary deposits, Pleistocene lake deposits, and Pleistocene lava flows. The aquifers of the valley are mainly alluvial fan and lake deposits. The alluvial fans grade laterally from the basin boundaries into coarse lake and stream deposits. The deposits of silt and clay act as aquitards or aquicludes in the formation. Aquiclude materials are predominantly fine-grained lake deposits. In the central part of the basin, alluvial, lake and basin deposits comprise the upper 30–200 feet of aquitard material that overlies a thick sequence of interstratified aquifers and aquicludes.

Holocene sedimentary deposits include alluvial fans and intermediate alluvium. Alluvial fans consist of unconsolidated gravel, sand, and silt with minor clay lenses. These deposits are located at the perimeter of the valley to a thickness of 200 feet. The fan deposits coalesce or interfinger with basin, lake, and alluvial deposits. Specific yield ranges from 8 to 17%. The fans are a major source of confined and unconfined groundwater and serve as important recharge areas.

Intermediate alluvium consists of unconsolidated silt and sand with lenses of clay and gravel. Specific yield is estimated to range from 5 to 25%. This unit is limited in extent and is found along streams and centrally in the basin. The deposits are up to 50 feet in thickness and yield moderate amounts of groundwater to shallow wells.

Lake deposits underlie the majority of the valley and range in thickness to 2,000 feet. These provide most of the groundwater developed in the valley. The deposits consist of slightly consolidated, bedded sand, silt, and diatomaceous clay with the sand beds yielding large amounts of groundwater to wells. Specific yield ranges from 1 to 25%. Well production reportedly ranges up to 3,200 gpm.

Pleistocene volcanic rocks consist of jointed and fractured basalt flows ranging in thickness from 50 to 300 feet. These rocks are moderately to highly permeable and yield large amounts of groundwater to wells. They also serve as a recharge area and, where buried by lake deposits, form confined zones with significant artesian pressures.

Increases in groundwater development in the mid-late 1970s resulted in the cessation of flow in many artesian wells and large pumping depressions formed over the areas where heavy pumping occurred. Water levels in a flowing artesian well in the northeast portion of the basin declined to more than 50 feet below ground surface by the early 1990s, when reductions in groundwater pumpage occurred. Through the 1990s groundwater levels in the basin have recovered to mid 1970s levels.

The estimated groundwater storage in the basin is 7,500,000 acre-feet to a depth of 1,000 feet. The quantity of water that is useable is unknown. Based on an estimated specific yield ranging from 5 to 8%, storage capacity is estimated to be between 1,000,000 and 1,800,000 acre-feet for the top 200 feet of sediments. These estimates include the Chilcoot Subbasin (5-12.02).

Based on a 1997 DWR survey of land use and sources of water, estimates of groundwater extraction for agricultural and municipal/industrial uses are 3,400 and 110 acre-feet per year respectively.

As of 1975, the average well yield was 300 gpm, with a max yield of 1,800 gpm. Groundwater pumpage, at the time of the 1975 report, was below safe yield (DWR 1978).

Major Sources of Recharge

Most of the upland recharge areas are composed of permeable materials occurring along the upper portions of the alluvial fans that border the valley. Recharge to groundwater is primarily by way of infiltration of surface water from the streams that drain the mountains and flow across the fans. Annual precipitation ranges from 13 inches in the valley to 29 inches in the upland areas to the south and west. Deep percolation from applied water is estimated to be 2,100 acre-feet per year. (DWR 2004.)

Land Use

Groundwater development, as of 1975, was limited to irrigation, domestic, and stock use, with a potential for moderate to high additional development (DWR 118-75).

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land use accounts for about 33% of the subbasin, urban land use accounts for about 1% of the subbasin, and native land accounts for about 66% of the subbasin. Table 4-99 provides details on the distribution of land use throughout the Sierra Valley subbasin.

Table 4-99. Land Use in the Sierra Valley Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	2,014	1.71
Idle	1,313	1.12
Pasture	34,507	29.34
Semiagricultural and Incidental	469	0.40
Truck, Nursery, and Berry Crops	451	0.38
Subtotal	38,753	32.95
Urban		
Urban—unclassified	426	0.36
Commercial	37	0.03
Industrial	237	0.20
Urban Landscape	28	0.02
Urban Residential	420	0.36
Vacant	143	0.12
Subtotal	1,292	1.10
Native		
Riparian	7,765	6.60
Native Vegetation	69,631	59.20

Land Use	Acreage of Land Use	Percent of Land Use
Water	183	0.16
Subtotal	77,579	65.95
Total	**117,625**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Water agencies within the subbasin include Loyalton Water District (public agency), Sierra Valley PUD (public agency), and Sierra Brooks Subdivision (private). Groundwater management for this subbasin is under the Sierra Valley Groundwater Management District (authorized by Senate Bill 1391, enacted in 1980) (DWR 2004). This subbasin falls within the area included in the Upper Sacramento Valley Water Quality Coalition.

Water Quality

A wide range of mineral type waters exists throughout the basin. Sodium chloride and sodium bicarbonate type waters occur south of Highway 49 and north and west of Loyalton along fault lines. Two wells have waters that are sodium sulfate in character. In other parts of the valley the water is bicarbonate with mixed cationic character. Calcium bicarbonate type water is found around the rim of the basin and originates from surface water runoff. TDS in the basin range in concentration from 110 to 1,620 mg/L, averaging 312 mg/L.

The poorest quality groundwater is found in the central west side of the valley where fault-associated thermal waters and hot springs yield water with high concentrations of boron, fluoride, iron, and sodium (DWR 2004). Several wells in this area also have high arsenic and manganese concentrations.

Boron concentrations in thermal waters have been measured in excess of 8 mg/L. At the basin fringes, boron concentrations are usually less than 0.3 mg/L. There is also a sodium hazard associated with thermal waters and some potential for problems in the central portion of the basin (DWR 2003, 2004).

Squaw Flat Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of the Squaw Flat Groundwater Basin is 2 square miles (1,300 acres) and is located in Glenn County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Squaw Flat Basin is located due east of the Stony Gorge Reservoir Groundwater Basin. The basin is bounded on all sides by upper Cretaceous marine deposits. The basin consists of Quaternary alluvial deposits and is drained to the east by Logan Creek.

Hydrologic information was not available from DWR for the following: water-bearing formations, groundwater level trends, storage, budget, and groundwater quality.

Major Sources of Recharge

The primary source of recharge is precipitation which is approximately 18 inches per year (DWR 2004).

Land Use

Land use surveys were conducted in Glenn County by DWR in 1998. All acreage in the Squaw Flat Basin is designated as native vegetation.

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County adopted a groundwater management ordinance for the Squaw Flat Basin in 2000. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Stony Gorge Reservoir Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Stony Gorge Reservoir Groundwater Basin is 2 square miles (1,070 acres) in size and is located in Glenn County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Stony Gorge Reservoir Basin is located due south of Stony Gorge Reservoir. It is bounded on the east and northwest by lower Cretaceous marine deposits and bounded on the west by rocks of the Knoxville Formation. The basin consists of Quaternary alluvial deposits.

Additional hydrogeologic information was not available from DWR for the water-bearing formations, groundwater level trends, or groundwater storage in the basin. Based on a 1993 DWR survey of land use and water sources, groundwater extraction for municipal/industrial use in the basin is estimated to be 8 acre-feet.

Major Sources of Recharge

Precipitation is the primary source of recharge and is approximately 18 inches per year. Deep percolation of applied water is estimated to be 38 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about9% of the basinand native land use accounts for about 91% of the basin. Table 4-100 provides details on the distribution of land use throughout the Stony Gorge Reservoir Basin.

Table 4-100. Land Use in the Stony Gorge Reservoir Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Idle	43	4.00
Pasture	40	3.74
Semiagricultural and Incidental	9	0.88
Subtotal	92	8.63
Native		
Barren and Wasteland	91	8.55
Riparian	30	2.83
Native Vegetation	808	75.81
Water	45	4.19
Subtotal	974	91.37
Total	**1,066**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County adopted a groundwater management ordinance in 2000. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

There is no groundwater quality data for this basin.

Stonyford Town Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Stonyford Town Area Groundwater Basin is 10 square miles (6,440 acres) in size and is located in Glenn and Colusa Counties. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Stonyford Town Area Basin consists of Quaternary stream terrace deposits and may be bounded on several sides by faulting of the Stony Creek Fault System. The basin is bounded to the west by Mesozoic Franciscan volcanic and metavolcanic rocks, to the north by metasedimentary rocks of the Franciscan Formation and Mesozoic ultrabasic intrusive rocks and the Knoxville Formation.

Additional hydrologic information was not available from DWR for water-bearing formations, groundwater level trends, and groundwater storage in the basin. Based on a 1993 DWR survey of land use and water sources, groundwater extraction for municipal and industrial uses is estimated to be 35 acre-feet.

Total depths of domestic wells completed in the basin range from 30 to 220 feet, with an average of 108 feet (based on 40 well completion reports). Total depth of the single irrigation well reported in the basin is 76 feet. No information on well yield was found.

Major Sources of Recharge

Precipitation is the primary source of recharge and ranges from 21 to 23 inches per year. Deep percolation of applied water is estimated to be 400 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted in Glenn and Colusa Counties by DWR in 1998. Agricultural land use accounts for about 20% of the basin, urban land use accounts for about 2% of the basin, and undeveloped land accounts for more than 77% of the basin. Table 4-101 provides details on the distribution of land use throughout the basin.

Table 4-101. Land Use in the Stonyford Town Area Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	43	0.67
Idle	486	7.54
Pasture	734	11.40
Semiagricultural and Incidental	34	0.52
Subtotal	1,297	20.13

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Commercial	4	0.07
Industrial	10	0.15
Urban Residential	135	2.09
Vacant	9	0.14
Subtotal	157	2.44
Native		
Barren and Wasteland	64	0.99
Riparian	5	0.07
Native Vegetation	4,879	75.74
Water	40	0.62
Subtotal	4,988	77.43
Total	**6,442**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County adopted a groundwater management ordinance in 2000. Colusa County adopted a groundwater management ordinance in 1998. There are no public or private water agencies in the basin. Both these ordinances limit groundwater exports from the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Between 1994 and 2000, groundwater in the Stonyford Town Area Basin was sampled for primary inorganics, radiologicals, nitrates, pesticides, VOCs and SVOCs, and secondary inorganics, as required under CDPH Title 22 program. None of the constituents were detected at concentrations above MCL in either of the 2 wells sampled (DWR 2004).

Toad Well Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Toad Well Area groundwater basin is located in Siskiyou County and is 3,360 acres (5 square miles) in size. The Toad Well Area Groundwater Basin is a fault-bounded basin consisting of Quaternary alluvial deposits. Faults bound both the east and west sides of the basin. The basin is bounded to the west by Tertiary basalt of Buck Mountain and on all other sides by Pleistocene basalt.

Major Sources of Recharge

Recharge to the basin is from precipitation and stream infiltration. The average annual precipitation ranges from 55 to 57 inches. (DWR 2004.)

Land Uses

Land use surveys were conducted within the basin by DWR in 2000. The land use within the Toad Well Area Basin is entirely native (Table 4-102).

Table 4-102. Land Use in the Toad Well Area Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	3,360	100.00
Total	**3,360**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Siskiyou County adopted a groundwater management ordinance in 1998. Groundwater ordinances generally affect the volume of groundwater that can be pumped and/or exported from the basin. There are no major urban areas within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality datafor this basin could not be identified.

Upper Lake Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Upper Valley Basin is 11 square miles in size and is located in Lake County. The following description of the hydrogeology in the Upper Lake Basin is taken from DWR Bulletin 118 (2004).

The Upper Lake Basin is an irregularly shaped basin at the north end of Clear Lake that includes Middle Creek Valley, Clover Valley, and Bachelor Valley, all of which extend to a main central valley opening to the south to Clear Lake. Middle Creek Valley and Clover Valley are bounded by Middle Mountain to the west and Pitney and Hogback Ridges to the east.

Middle Mountain is a fault-bounded block underlain by sandstone and shale of the Great Valley Sequence. Pitney and Hogback Ridges consist mainly of graywacke sandstone and shale with minor interbedded basalt and chert of the Jurassic-Cretaceous Franciscan Formation. Similar rock types also underlie the mountain ridge south of Tule Lake located west of the basin.

The contact between the bedrock materials bounding the unconsolidated alluvium generally defines the basin boundary. Bedrock units in the area include the Franciscan Formation and the Great Valley Sequence.

The aquifer system in the Upper Lake Basin is composed primarily of Quaternary alluvial deposits and Pleistocene terrace, lake, and floodplain deposits. The alluvium, lake, and floodplain deposits fill the valleys and contain nearly all water yielded to wells. The older Cretaceous and Jurassic formations generally form the uplands surrounding the alluvial basin.

Groundwater within bedrock mainly occurs in near surface fractures along the lower hills. Generally, groundwater in bedrock has not been developed. Bedrock units and terrace deposits yield very little water to wells.

The Quaternary alluvial deposits include channel alluvium, fan deposits, and older alluvium consisting of gravel, sand, and fines. The active channels of Middle Creek, Alley Creek, and Clover Creek, and all other smaller creeks that drain the area around the Upper Lake Basin are underlain by uncemented gravel and sand, with silt and clay lenses. Fan and older alluvial deposits occur at the mouths of some ravines and small canyons that enter into the valley. These deposits consist of a mixture of gravel, sand, and fines and reach a thickness of 40–50 feet. The thickness of the deposits decreases downstream to just a few feet.

The Pleistocene terrace deposits border the west and northwest sides of Middle Creek Valley and exist as isolated remnants above the valley floor. The deposits consist of poorly consolidated clay, silt, and sand with some gravel lenses. The deposits generally have a low permeability due to their high clay content and are less important as a groundwater source.

Fine grained lacustrine sediments and coarser grained floodplain deposits underlie the valley floors of Middle, Clover, and Alley creeks. These deposits overlie bedrock and older unconsolidated sediments. These sediments generally range in thickness from about 60 to 110 feet and, in the Middle Creek Valley area, form a confining layer for an underlying artesian aquifer system. The fine-grained lake deposits also contain numerous sand and gravel lenses representing portions of former stream channels. Permeability of the fine-grained lake deposits is low with specific yields ranging from about 3 to 5%. Sand and gravel lenses yield an average of 230 gpm.

The Cache Creek formation is a pre-terrace alluvial deposit consisting of lacustrine clays, sands, and gravels that overly bedrock in some places along the borders of the valley. The permeability of the formation is generally low.

The average specific yield for the depth interval of 0–100 feet is estimated to be 8% based on review and analysis of well logs for the Upper Lake Basin. The storage capacity for the basin is 10,900 acre-feet. The useable storage capacity is estimated to be 5,000 acre-feet. According to a 1995 survey, estimates of groundwater extraction for agricultural and municipal/industrial uses are 4,100 and 190 acre-feet respectively.

Major Sources of Recharge

Recharge of the principal aquifer is from Middle Creek, Clover Creek, and Alley Creek, and precipitation in the basin ranges from 35 to 43 inches per year, increasing to the north. Deep percolation from applied water is estimated to be 2,100 acre-feet per year. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 48% of the basin, urban land use accounts for about 10% of the basin, and native land use accounts for about 42% of the basin. Table 4-103 provides details on the distribution of land use throughout the Upper Lake Basin.

Table 4-103. Land Use in the Upper Lake Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	1,181	16.26
Grain and Hay	111	1.52
Idle	353	4.85
Pasture	727	10.01
Rice	580	7.98
Semiagricultural and Incidental	84	1.16
Truck, Nursery, and Berry Crops	29	0.39
Vineyards	414	5.70
Subtotal	3,479	47.88
Urban		
Urban—unclassified	11	0.15
Commercial	50	0.68
Industrial	7	0.10
Urban Landscape	46	0.64
Urban Residential	595	8.18
Vacant	24	0.33
Subtotal	732	10.08
Native		
Riparian	513	7.06
Native Vegetation	2,447	33.68
Water	95	1.31
Subtotal	3,055	42.04
Total	**7,266**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

A groundwater management ordinance for Upper Lake Basin was adopted by Lake County in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). County of Lake is the only public water agency in Upper Lake Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Magnesium bicarbonate and calcium bicarbonate water are the predominant groundwater types in the basin. TDS ranges from 180 to 615 mg/L, averaging 500 mg/L.

Boron has been detected is some wells in the basin; however, high boron is not a prevalent condition. Water quality analyses show high iron, manganese, EC, calcium, ASAR, and TDS (DWR 2004).

Yellow Creek Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of the Yellow Creek Groundwater Basin is 2,310 acres and it is located in Plumas County, to the southwest of Lake Almanor. It consists of Quaternary alluvium. The valley is bounded to the east by Mesozoic and Paleozoic marine sediments, bounded to the north and west by Tertiary volcanic rocks, and to the south by Recent volcanic and Paleozoic marine sediments. The valley is drained to the south by Yellow Creek. (DWR 2004.)

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation and stream infiltration. Annual precipitation ranges from 39 to 43 inches (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 61% of the basin and native land use accounts for about 39% of the basin. There is no urban land in the Yellow Creek Valley basin. Table 4-104 provides details of the land uses within the basin.

Table 4-104. Land Use in the Yellow Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	1,410	61.04

Land Use	Acreage of Land Use	Percent of Land Use
Semiagricultural and Incidental	0	0.00
Subtotal	1,410	61.00
Native		
Native Vegetation	870	37.66
Riparian	30	1.30
Subtotal	900	39.00
Total	**2,310**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications. Therer are no know water agencies or urban areas. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

SAN JOAQUIN VALLEY GROUNDWATER BASIN—INTRODUCTION

The San Joaquin Valley Groundwater Basin lies within the San Joaquin River and Tulare Lake HRs. The northern portion of the basin is within the San Joaquin River HR and consists of nine subbasins. These are the Cosumnes, Eastern San Joaquin, Tracy, Modesto, Turlock, Merced, Delta-Mendota, Chowchilla, and Madera Subbasins (Figure 4-3). The southern portion of the basin lies in the Tulare Lake HR and consists of seven groundwater subbasins. These are the Kings, Westside, Kaweah, Tulare Lake, Pleasant Valley, Tule, and Kern Subbasins (Figure 4-4). The subbasins are described in detail below.

The San Joaquin River HR portion of the basin covers approximately 3.73 million acres, and the Tulare Lake HR portion of the basin covers approximately 5.15 million acres. Groundwater is extensively used in the San Joaquin Valley Groundwater Basin by agricultural and urban entities and accounts for approximately 48% of the groundwater used in California (DWR 2003).

Overview of Agricultural Chemical Impacts to Groundwater

This section presents a discussion of data that are on a more regional scale than any one subbasin; it is intended to provide an overview of agricultural chemical impacts to groundwater in the San Joaquin Valley Groundwater Basin.

The National Water Quality Assessment (NAQWA) for the San Joaquin Valley Groundwater Basin concluded that groundwater within the eastern portion of the San Joaquin Valley that supplies drinking water to the majority of the population has been degraded by fertilizers and pesticides (Dubrovsky et al. 1998). This report concluded that nitrate concentrations frequently exceeded drinking water standards while pesticides, with the exception of DBCP, rarely exceeded drinking water standards. The specific conclusions are listed below.

- Nitrate concentrations in groundwater in the eastern San Joaquin Valley exceeded drinking water standards in approximately 25% of domestic water supply wells sampled.
- Nitrate concentrations in shallow groundwater were related to agricultural land use settings. Detected concentrations were related to fertilizer application, physical characteristics of the sediment, and groundwater biochemical processes and varied among different agricultural land use settings.
- Since the 1950s, nitrate concentrations in groundwater have increased. During the same period, nitrogen fertilizer applications have increased from 114 to 745 million pounds per year.
- Pesticides were detected in approximately 67% of the groundwater samples collected from domestic water supply wells. However, most concentrations were less than 0.1 microgram per liter (µg/L).
- Detected pesticide concentrations generally did not increase between 1986 and 1995.

The occurrence of pesticides and nitrates in groundwater were studied in three agricultural land use settings in the eastern San Joaquin Valley (Burow et al. 1998). The concentration and occurrence of nitrates and pesticides in groundwater was related to differences in chemical applications and physical and biochemical processes at each of the three locations. Significant conclusions of the study are listed below.

- Groundwater beneath vineyard and almond land use settings is more vulnerable to non-point source contamination than groundwater beneath the corn, alfalfa, and vegetable (row crop) land use setting on the lower (more distal) part of the alluvial fan.
- Nitrate concentrations in groundwater beneath almond orchards are typically higher than nitrate concentrations in groundwater beneath vineyards because nitrate fertilizer application rates are typically higher in almonds than vineyards.
- Row crops on fine-grained sediments and low dissolved oxygen concentrations reflect processes that result in slow infiltration rates and longer groundwater residence times. Intermediate nitrate concentrations in groundwater are the result of these characteristics combined with typically high application rates.
- Nitrate concentrations in groundwater have increased with time.
- Twenty-three different pesticides were detected in 41 of 60 groundwater samples collected.
- At least one pesticide was detected in 80% of the groundwater samples collected from the vineyard land use setting, 70% of the groundwater samples collected from the almond land use setting, and 55% of the groundwater samples collected from the row crop land use setting.
- Simazine was the most commonly detected pesticide. Simazine was detected in 50% of the groundwater samples from the vineyard land use setting and in 30% of the groundwater samples from the almond and row crop land use setting,
- The occurrence of simazine, diuron, and DBCP was consistent with recent and historical use of these pesticides.
- The occurrence of atrazine was not directly related to crop use and may be related to applications on right-of-ways.

Domagalski and Dubrovsky (1991) completed a regional assessment of non-point source pesticide residues in groundwater of the San Joaquin Valley. Compounds detected in groundwater included atrazine, bromacil, 2,4-DP, diazinon, DBCP, prometon, prometryn, propazine, and simazine. Significant conclusions of this report are presented below.

- Pesticide leaching is dependent on application patterns, soil texture, total organic carbon in soil, pesticide half-life, and depth to groundwater.
- Leaching is enhanced by flood irrigation methods.
- Foliar-applied pesticides, such as diazinon, are not mobilized by flood irrigation and are less likely to be detected in groundwater.
- Shallower-occurring groundwater in the western San Joaquin Valley has fewer detected pesticides than groundwater in the eastern San Joaquin Valley. The finer-grained soils of the western San Joaquin Valley inhibit pesticide leaching due to either low vertical permeability or high surface area. Both properties enhance adsorption of pesticides in the soil.
- Soils in the eastern San Joaquin Valley are coarse-grained sediments derived from the Sierra Nevada Batholith. Unlike the fine-textured soils of the western San Joaquin Valley, these soils are susceptible to pesticide leaching and, particularly in areas where the water table is less than 100 feet, are vulnerable to groundwater degradation.

- The area that appears to be most susceptible to leaching is in eastern Fresno and Tulare Counties.
- Tritium was detected in samples where pesticides were detected. Tritium indicates recharge with water of recent origin (post 1952), indicating that the water recently interacted with soils. Tritium is a useful indicator of possible contamination of groundwater by pesticides.
- Nitrate concentrations were not significantly different in groundwater samples where atrazine was or was not detected. Nitrate is not a useful indicator of possible contamination of groundwater by pesticides.

Results from monitoring that was performed as part of the DPR Ground Water Protection Program are summarized in Table 4-105.

Table 4-105. Pesticide Detections in Groundwater Wells for Counties in the San Joaquin Valley Groundwater Basin (1985–2003)

County	ACET	Atrazine	Bentazon	Bromocitl	DACT	DEA	Diuron	Norflurazon	Promoton	Simizine
Amador										
Calaveras										
Contra Costa		1		1			1		2	1
Fresno	121	10		54	70	7	107	21	4	180
Kings		1					3		1	
Mariposa										
Madera	4	2		2	3	2	6			4
Merced	8	4	1	3	8	2	7	1	1	6
San Joaquin	19	7		5	15	10	7	1		7
Stanislaus	5	4	3	1	2	1	7		1	11
Tulare	70	24		145	30	10	250	14	8	282
Tuolumne										
Total	**227**	**53**	**4**	**211**	**128**	**32**	**388**	**37**	**17**	**491**

Notes:
ACET = 2-amino-4-chloro-6-ethylamino-s-triazine.
DACT = 2,4-diamino-6-chloro-s-triazine.
DEA = deethyl-atrazine.
Source: DPR Ground Water Protection Program. 2003 Well Inventory Database, Cumulative Report 1986-2003.

SAN JOAQUIN VALLEY GROUNDWATER BASIN— SAN JOAQUIN RIVER HYDROLOGIC REGION SUBBASINS

Cosumnes Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cosumnes Subbasin is within the San Joaquin River HR and comprises an area of approximately 281,000 acres (439 square miles), primarily in Sacramento and San Joaquin counties with a small portion of the subbasin in western Amador County (Figure 4-3). The subbasin is bounded on the south and southwest by the Eastern San Joaquin Subbasin and on the north by the South American Subbasin of the Sacramento Valley Groundwater Basin. Exposed bedrock of the Sierra Nevada comprises the eastern boundary of the subbasin.

Water-bearing units in the subbasin consist of continental deposits of the Miocene to Pliocene Mehrten Formation, older alluvium of Pliocene to Pleistocene age, and younger alluvium of Quaternary age. The cumulative thickness of these deposits ranges from a few hundred feet on the east near the Sierra Nevada foothills to over 2,500 feet along the western margin of the subbasin.

The Mehrten Formation crops out in a discontinuous band along the eastern margin of the subbasin and consists of gravels, sands, silt, and clay with interbedded tuff breccias. The sands and gravels are highly permeable with wells completed in these zones having high yields. The tuff breccias act as confining layers. Unit thickness ranges from 200 to 1,200 feet.

The older alluvium consists of loose to moderately compacted sand, silt, and gravel deposited in alluvial fans. Formation names assigned to these deposits include: Modesto Formation, Riverbank Formation, Victor Formation, Laguna Formation, Arroyo Seco Gravels, South Fork Gravels, and Fair Oaks Formation. These deposits crop out between the Sierra Nevada foothills and younger alluvium near the axis of the Valley. Unit thickness ranges from about 100 to 650 feet.

The younger alluvium consists of recent stream channel deposits and dredge tailings. The stream channel deposits include sediments laid down by active steams, terrace deposits, and overbank deposits. These deposits consist of silt, fine- to medium-grained sand, and gravels and occur primarily along the Sacramento, Cosumnes, and Mokelumne Rivers.

Major Sources of Recharge

The primary source of recharge to the area is seepage from streams flowing from the Sierra Nevada and percolation of applied irrigation water. The estimated total annual natural and applied water recharge is approximately 270,000 acre-feet. Estimated groundwater extraction includes approximately 35,000 acre-feet annually for urban use and 94,000 acre-feet annually for agricultural use (DWR 2003).

Land Use

Land use within the approximately 281,000-acre subbasin is shown on Figure 4-5. Primary agricultural crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-106.

Table 4-106. Land Use in the Cosumnes Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	3,500
Field Crops	15,000
Grain and Hay	4,000
Pasture	23,000
Truck, Nursery, and Berry Crops	2,000
Vineyards	33,500
Total	**81,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Public entities within the Cosumnes Groundwater Subbasin are: Galt ID, Jackson Valley ID, North Delta WA, North San Joaquin WCD, Omochumne-Hartnell WD, Clay WD, Amador WA, Calaveras County WD, City of Galt Service Area, Rancho Murieta CSD, Sacramento County WD, Sacramento County MUD, and North San Joaquin WCD.

Identified water quality coalitions in the Cosumes Groundwater Subbasin are the Sacramento Valley Water Quality Coalition in the Sacramento County portion of the subbasin and the San Joaquin County and Delta Coalition in the San Joaquin County portion of the subbasin.

There are no major urban areas in the Cosumnes Subbasin.

San Joaquin County adopted a groundwater management ordinance in 1996 and an amendment in 2000 regarding extracting and exporting of groundwater from San Joaquin County. The ordinance requires that a permit be obtained for use of extracted groundwater outside the County boundaries.

Sacramento Metropolitan Water Authority adopted an AB 3030 groundwater management plan in 1994. Agencies within the subbasin that are part of the authority include Galt ID, Hartnell WD, Clay WD, City of Galt Service Area, and Rancho Murieta CSD.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in San Joaquin County and 566 wells in Sacramento County for analysis of pesticides. Verified detections of pesticides were reported in 45 wells in San Joaquin County and 3 wells in Sacramento County. Unverified detections of pesticides were reported in 84 wells in San Joaquin County and 31 wells in Sacramento County. Detected pesticides include atrazine and bentazon in Sacramento County with ACET, atrazine, bromacil, DACT, DEA, diuron, norflurazon, and simazine detected in San Joaquin County (Schuette et al. 2003).

Groundwater samples collected from 1994 to 2000, from 22 public water supply wells to meet the requirements of Title 22 of the California Code of Regulations (Title 22) within the Cosumnes Subbasin were analyzed for pesticides. Pesticides were detected in groundwater from one well at a concentration that exceeded the applicable MCL (DWR 2003).

Inorganic Constituents

Groundwater within the subbasin is typically a calcium-magnesium and calcium-sodium bicarbonate type water. Detected TDS concentrations range from 140 to 438 mg/L and average approximately 218 mg/L. Nitrate levels were below the MCL in 30 public supply wells sampled by CDPH (DWR 2003).

Eastern San Joaquin Subbasin

General subbasin parameters, water quality, and discharge pathways and sources of contaminants are discussed below.

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Eastern San Joaquin Subbasin is within the San Joaquin River HR and comprises an area of approximately 707,000 acres (1,110 square miles) in San Joaquin, Stanislaus, and Calaveras Counties (Figure 4-3). The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2004).The subbasin is bounded by the Modesto Subbasin on the south, Delta-Mendota Subbasin on the southwest, Tracy Subbasin on the west, and on the north and northwest by the Cosumnes, South Sacramento, and Solano Subbasins. The Solano and South American Subbasins are part of the Sacramento Valley Groundwater Basin.

Water-bearing units of the subbasin include undifferentiated deposits of alluvium and Modesto/Riverbank Formations, flood basin deposits, Laguna Formation, and Mehrten Formation.

The undifferentiated deposits of alluvium and the Modesto/Riverbank Formations are of Recent to Late Pleistocene in age and consist of sand and gravels deposited in alluvial fans and clay, silt, and sand deposited in interfan areas. These units range in thickness from a thin veneer along the eastern margin of the subbasin to 150 feet near the center of the valley.

The flood-basin deposits consist of Recent to Pliocene age sediments exposed in the delta area of the San Joaquin Valley. These sediments represent a finer-grained equivalent (more distal facies) of the alluvium and Modesto/Riverbank Formations as described above. These deposits consist primarily of fine-grained sand, silt, and clay with occasional gravel beds. Unit thickness ranges from 0 to 1,400 feet. This unit creates semi-confined to confined conditions when interfingered with coarser-grained deposits. This unit typically has low permeability and contains poor quality groundwater.

The Plio-Pleistocene Laguna Formation consists of discontinuous lenses of fluvial sand and silt with lesser amounts of clay and gravel. The unit thickens from approximately 400 feet near the Mokelumne River to 1,000 feet in the Stockton area.

The Miocene to Pliocene Mehrten Formation consists of moderately to well indurated andesitic sand interbedded with conglomerate, tuffaceous siltstone, and claystone. The unit is exposed along the eastern margin of the subbasin where it is approximately 400 feet thick. The unit appears to thicken westward in the subsurface with reported thicknesses of 600 feet near Stockton and 1,300 feet near McDonald Island.

Estimated groundwater extraction includes approximately 47,000 acre-feet annually for municipal and industrial use and 762,000 acre-feet annually for agricultural use (DWR 2003).

Major Sources of Recharge

The primary source of recharge to the area is seepage from streams flowing from the Sierra Nevada and percolation of applied irrigation water. The estimated total annual recharge is 593,000 acre-feet from precipitation and applied water, 141,000 acre-feet from infiltration of surface water, and 3,500 acre-feet of net subsurface inflow.

Land Use

Land use within the approximately 707,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-107.

Table 4-107. Land Use in the Eastern San Joaquin Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	102,500
Field Crops	70,500
Grain and Hay	55,000
Pasture	65,500
Truck, Nursery, and Berry Crops	44,000
Vineyards	59,000
Total	**396,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Public water entities within the Eastern San Joaquin Groundwater Subbasin include: Lockeford CSD, North Delta WA, North San Joaquin WCD, Oakdale ID, City of Lathrop WD, City of Lodi Service Area, City of Manteca WSA, Calaveras County WD, California Water Service Company, Central Delta WA, Central San Joaquin WCD, City of Escalon WSA, Reclamation District 828, River Junction Reclamation District 2064, Rock Creek WD, South Delta WA, South San Joaquin ID, Stockton East WD, Valley Springs PUD, Woodbridge ID, Woodbridge WUCD, San Joaquin County FC&WCD, and City of Stockton MUD.

Coalitions in the subbasin include the San Joaquin County & Delta Coalition in the San Joaquin County portion of the subbasin and the East San Joaquin River Water Quality Coalition in the Stanislaus County portion of the subbasin.

San Joaquin County adopted a groundwater management ordinance in 1996 and an amendment in 2000, regarding extracting and exporting of groundwater from San Joaquin County. The ordinance requires that a permit be obtained for use of extracted groundwater outside the County boundaries.

Calaveras County adopted a groundwater management ordinance in 2002. The ordinance requires that a permit be obtained for extracting groundwater for use outside the County.

AB 3030 groundwater management plans have been adopted by Stanislaus County, Oakdale ID, San Joaquin County FC&WCD, South San Joaquin ID, Stockton East WD, and Woodbridge WD.

Major urban areas in the subbasin include the Cities of Stockton and Lodi.

Water Quality

Water quality relating to pesticide and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in San Joaquin County and 900 wells in Stanislaus County for analysis of pesticides. Groundwater samples from 45 wells in San Joaquin County and 45 wells in Stanislaus County had verified detections of pesticides. San Joaquin County had 84 unverified detections while Stanislaus had 171 unverified detections. Pesticides detected in both counties include: ACET, atrazine, bromacil, DACT, DEA, diuron, and simazine. In addition, the pesticides bentazon and prometon were detected in Stanislaus County and norflurazon was detected in San Joaquin County (Schuette et al. 2003).

Inorganic Constituents

Most groundwater within the subbasin is calcium-magnesium bicarbonate or calcium-sodium bicarbonate type water. Along the western margin of the subbasin near the San Joaquin River, chloride becomes the dominant anion. Analysis of groundwater samples from 174 water supply wells in the subbasin detected

TDS concentrations from 30 to 1,632 mg/L with an average of 310 mg/L. Other studies have reported TDS concentrations of groundwater ranging from 463 mg/L to 3,520 mg/L with an average of 463 mg/L. (DWR 2003.)

Large areas of the subbasin southeast of Lodi and south of Stockton and east of Manteca (extending toward the Stanislaus-San Joaquin County line have elevated concentrations of nitrates (DWR 2003).

Intrusion of saline water has been occurring along a 16-mile front on the east side of the Delta. The front moved approximately 1 mile east from 1963 to 1996. It is believed that declining groundwater levels have allowed the intrusion of saline water (DWR 2003).

Tracy Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Tracy Subbasin is within the San Joaquin River HR and comprises an area of approximately 345,000 acres (539 square miles) in San Joaquin, Contra Costa, and Alameda Counties (Figure 4-3). The subbasin is bounded by the Solano subbasin of the Sacramento Groundwater Basin to the north, the Eastern San Joaquin Subbasin to the east, and the Delta-Mendota Subbasin to the south.

Water-bearing units of the Tracy Subbasin consist of Late Tertiary to Quaternary continental deposits of the Tulare Formation, older alluvium, flood basin deposits, and younger alluvium. The cumulative thickness of these deposits ranges from a few hundred feet along the edge of the Coast Ranges to about 3,000 feet along the eastern margin of the subbasin.

The Tulare Formation is exposed in the Coast Ranges west of the subbasin and dips eastward towards the axis of the valley. This unit consists of discontinuous deposits of clay, silt, and gravel that are poorly sorted and semi-consolidated. The Corcoran clay (also referred to as the e-clay) occurs near the top of the formation and confines groundwater beneath. The eastern limit of the Corcoran clay is near the eastern subbasin boundary. Groundwater is produced both from the unconfined aquifer above the Corcoran clay and the confined aquifer below. However, poor quality water is often encountered above the Corcoran clay. Maximum thickness of the Tulare Formation is about 1,400 feet.

The older alluvium is commonly exposed between the Coast Ranges and the Delta. This unit consists of loosely to moderately compacted sand, silt, and gravel deposited in alluvial fans during the Plio-Pleistocene. The older alluvium is about 150 feet thick.

The younger alluvium includes channel and overbank deposits of active streams and terrace deposits of those streams. These deposits are present primarily along Corral Hollow Creek and consist of unconsolidated silt, fine- to medium-grained sand, and gravel. This unit is less than 100 feet thick in the subbasin.

Flood basin deposits occur in the Delta portion of the subbasin. This unit consists primarily of silt and clay with occasional gravel interbeds and is the distal equivalent of the older and younger alluvium and the Tulare Formation. Groundwater found within this unit, it is generally of poor quality. The maximum thickness of the flood basin deposits is about 1,400 feet.

Major Sources of Recharge

The primary source of recharge to the area is seepage from streams and percolation of applied irrigation water.

Land Use

Land use within the approximately 345,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-108.

Table 4-108. Land Use in the Tracy Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	17,000
Field Crops	63,500
Grain and Hay	28,500
Pasture	47,500
Truck, Nursery, and Berry Crops	45,000
Vineyards	2,500
Total	**204,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The San Joaquin County and Delta Coalition is the only identified water quality coalition in the subbasin.

Identified public agencies within the Tracy Groundwater Subbasin are: Naglee Burk ID, North Delta WA, Contra Costa WD, Diablo WD, East Contra Costa WD, Alameda CFC&WCD, Banta-Carbona WD, Byron Bethany ID, Central Delta WA, City of Antioch WSA, City of Brentwood WSA, Pescadero RD 2058, Plain View WD, RD 2039, South Delta WA, Stockton-East WD, The West Side ID, and West Stanislaus ID.

San Joaquin County adopted a groundwater management ordinance in 1996 and an amendment in 2000, regarding extraction and exportation of groundwater from San Joaquin County. The ordinance requires that a permit be obtained for use of extracted groundwater outside the County boundaries.

The San Luis and Delta-Mendota Water Authority has adopted an AB 3030 groundwater management plan. The water authority is composed of the Banta-Carbona ID, City of Tracy, Del Puerto WD, Patterson WD, Plain View WD, San Joaquin County FC&WCD, West Side ID, and West Stanislaus ID.

The only identified major urban area is the City of Tracy.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in San Joaquin County for analysis of pesticides. Groundwater samples from 45 of the wells had verified detections of pesticides and 84 of the wells had unverified detections. Pesticides detected included: ACET, atrazine, bromacil, DACT, DEA, diuron, norflurazon, and simazine (Schuette et al. 2003). DPR also reported data for Alameda and Contra Costa Counties; however, it is not summarized here because only a minor portion of each county is within the Tracy Subbasin.

Inorganic Constituents

Groundwater beneath the northern part of the subbasin is a sodium bicarbonate, chloride, and mixed bicarbonate-chloride type water. The dominant cations in groundwater beneath the southern part of the subbasin are calcium and sodium while the anionic water type is sulfate to chloride and bicarbonate to chloride. TDS concentrations in San Joaquin and Contra Costa counties range from 50 to 3,520 mg/L with a mean of 463 mg/L. The highest TDS concentrations are found in the western and central parts of the subbasin. Analysis of groundwater samples from 36 water supply wells within the subbasin had TDS concentrations from 210 to 7,800 mg/L with an average of 1,190 mg/L (DWR 2003).

The northwestern part of the subbasin and around the city of Tracy has high nitrate levels. Boron is also elevated from the northwest side of the subbasin to just south of Tracy. Elevated chloride concentrations exist in several areas of the subbasin including: along the San Joaquin River, the northwestern part of the subbasin, and in the vicinity of the City of Tracy (DWR 2003).

Modesto Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Modesto Subbasin is within the San Joaquin River HR and comprises an area of approximately 247,000 acres (385 square miles) in Stanislaus County (Figure 4-3). The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The subbasin is bounded by the Stanislaus River to the north, San Joaquin River to the west, and Tuolumne River to the south. The Eastern San Joaquin Subbasin is to the north, Delta-Mendota Subbasin is to the west, Turlock Subbasin is to the south, and bedrock of the Sierra Nevada is to the east.

Water-bearing units of the subbasin include consolidated and unconsolidated sedimentary deposits. The consolidated deposits include the Tertiary age Ione, Valley Springs, and Mehrten Formations.

Unconsolidated deposits include Pliocene and younger deposits that from oldest to youngest have been identified as continental deposits, lacustrine and marsh deposits, older alluvium, younger alluvium, and flood basin deposits.

The consolidated deposits are exposed along the eastern edge of the subbasin and only the Mehrten is considered an important aquifer. The Ione and Valley Springs yield only limited quantities of water to wells. The Mehrten is composed of up to 300 feet sandstone, breccia, conglomerate, tuff siltstone, and claystone.

The continental deposits and the older alluvium are the primary water-bearing units of the unconsolidated deposits. The continental deposits consist primarily of poorly sorted gravel, sand, silt, and clay with a maximum thickness of about 450 feet.

The older alluvium consists of interstratified beds of gravel, sand, silt, and clay. This unit is up to 400 feet thick and is typically at or near the surface of the western half of the subbasin. This unit is equivalent of the Modesto and Riverbank Formations.

The Corcoran clay occurs within the lacustrine and marsh deposits. The Corcoran clay is the confining layer that separates the overlying unconfined aquifer from the underlying confined aquifer. The Corcoran clay underlies the southwestern portion of the subbasin at depths of 150 to 250 feet (DWR 2003).

Estimated annual groundwater extractions include 81,000 acre-feet for urban use and 145,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary sources of groundwater recharge in the subbasin are from deep percolation of applied irrigation water and from canals and water storage facilities. Lesser groundwater recharge occurs from percolation from small streams, direct percolation of precipitation, and underflow downstream channels from the east. The lower to middle stretches of the Stanislaus and Tuolumne rivers are gaining streams with groundwater discharge supporting flow. Natural recharge to the subbasin is estimated at 86,000 acre-feet annually with an additional 92,000 acre-feet of recharge from applied water annually.

Land Use

Land use within the approximately 247,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-109.

Table 4-109. Land Use in the Modesto Subbasin

Land Use	Approximate Acreage
Agriculture	
Rice	2,000
Deciduous Fruits and Nuts	44,000
Field Crops	20,000
Grain and Hay	3,500
Pasture	37,000
Truck, Nursery, and Berry Crops	1,500
Vineyards	5,500
Total	**113,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition in the subbasin is the East San Joaquin River Water Quality Coalition. Public water agencies within the Modesto Groundwater Subbasin are: Modesto ID, Oakdale ID, Stanislaus and Tuolumne Rivers Groundwater Subbasin Association, City of Modesto, City of Oakdale, and City of Riverbank.

The only major urban area in the subbasin is the City of Modesto.

There are no pertinent groundwater ordinances or regulations in Stanislaus County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in Stanislaus County for analysis of pesticides. Groundwater samples from 45 of the wells had verified detections of pesticides and 171 of the wells had unverified detections. Detected pesticides included ACET, atrazine, bentazon, diuron, bromacil, DACT, DEA, prometon, and simazine (Schuette et al. 2003). Groundwater samples collected from 117 water supply wells regulated by the CDPH within the subbasin from 1994 through 2000 were analyzed for pesticides. Pesticides were detected in groundwater from 14 wells at concentrations greater than applicable MCL (DWR 2003).

Inorganic Constituents

Groundwater beneath the eastern part of the subbasin is typically a calcium bicarbonate type water while groundwater beneath the western portion of the subbasin is typically a calcium-magnesium bicarbonate or calcium-sodium bicarbonate type water. TDS concentrations range from 60 to 8,300 mg/L and typically fall between 200 and 500 mg/L. Analysis of 88 groundwater samples from wells regulated by CDPH had TDS concentrations ranging from 60 mg/L to 860 mg/L with an average concentration of 295 mg/L (DWR 2003).

There are localized areas of high chloride, boron, DBCP, nitrate, iron, and manganese. The eastern side of the subbasin has some areas with elevated sodium chloride and high TDS. 114 groundwater samples for analysis of nitrate were collected from water supply wells regulated by CDPH from 1994 through 2000. Three of these wells contained groundwater with nitrate concentrations greater than the MCL (DWR 2003).

Turlock Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Turlock Subbasin is within the San Joaquin River HR and covers approximately 347,000 acres (542 square miles) in Stanislaus and Merced Counties (Figure 4-3). The subbasin is bounded to the north by the Tuolumne River, to the south by the Merced River, and to the west by the San Joaquin River. The Modesto subbasin lies to the north, Delta-Mendota subbasin to the west, and Merced Subbasins to the south with bedrock of the Sierra Nevada to the east.

Water-bearing units of the subbasin include consolidated and unconsolidated sedimentary deposits. The consolidated deposits include the Tertiary age Ione, Valley Springs, and Mehrten Formations. Unconsolidated deposits include Pliocene and younger deposits that from oldest to youngest have been identified as continental deposits, older alluvium, younger alluvium, and flood basin deposits.

The consolidated units include the Ione, Valley Springs, and Mehrten Formations. Most of the consolidated material lies in the eastern portion of the subbasin and yield little water with the exception of the Mehrten Formation. The Mehrten Formation is composed of up to 800 feet of sandstone, breccia, conglomerate, tuff siltstone, and claystone.

Unconsolidated materials include continental, older, and younger alluvium, and flood basin deposits. In the western half of the subbasin the Corcoran or E-clay aquitard is composed of lacustrine and marsh deposits ranges at depths between about 50 and 200 feet. The lacustrine, flood-subbasin deposits and marsh deposits yield very little water. The younger alluvium yields only moderate quantities of water.

Given the stratigraphy of the Turlock Subbasin, there are three groundwater bodies: unconfined, semiconfined and confined in the consolidated material, and the confined water beneath the E-clay in the western portion of the subbasin.

Annual groundwater extraction is estimated at 65,000 acre-feet for urban use and 387,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary sources of groundwater recharge in the subbasin are from deep percolation of applied irrigation water and from canals and water storage facilities. Lesser groundwater recharge occurs from percolation from small streams, direct percolation of precipitation, and underflow downstream channels from the east. Natural recharge is estimated at 33,000 acre-feet annually while recharge of applied water is estimated at 313,000 acre-feet annually.

Land Use

Land use within the approximate 347,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-110.

Table 4-110. Land Use in the Turlock Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	105,500
Field Crops	60,000
Grain and Hay	6,000
Pasture	42,500
Truck, Nursery, and Berry Crops	5,000
Vineyards	15,500
Total	**234,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition in the subbasin is the East San Joaquin River Water Quality Coalition.

Public water agencies within the Turlock Groundwater Subbasin include: Eastside WD, Turlock ID, Ballico-Cortez WD (inactive), and Merced ID.

The only identified major urban area in the subbasin is the City of Turlock.

There are no known groundwater ordinances or regulations in Merced or Stanislaus County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in Stanislaus County and 1,230 in Merced County for analysis of pesticides. In Stanislaus County, groundwater samples from 45 of the wells had verified detections and 171 of the wells had unverified detections of pesticides. In Merced County, groundwater samples from 25 of the wells had verified detections and 72 of the wells had unverified detection of pesticides. Detected pesticides included ACET, atrazine, bentazon, diuron, bromacil, DACT, DEA, prometon, and simazine (Schuette et al. 2003). Groundwater samples collected (1994-2000) from 117 public water supply wells within the subbasin from 1994 through 2000 were analyzed for pesticides. Pesticides were detected in groundwater from 14 wells at concentrations greater than applicable MCLs (DWR 2003).

Inorganic Constituents

Groundwater in the subbasin is typically a sodium-calcium bicarbonate type water with sodium bicarbonate and sodium chloride type waters at the western margin and in a small area of the north-central part of the subbasin. TDS ranges from 100 to 8,300 mg/L, but usually ranges from 200 to 500 mg/L. Analysis of groundwater samples collected from 71 wells regulated by CDPH had TDS concentrations from 100 to 930 mg/L, with an average of 335 mg/L. (DWR 2003)

Localized areas of the subbasin have groundwater with concentrations of nitrates, chlorides, boron, and DBCP that impair the beneficial uses. In eight of the 90 public supply wells between 1994 and 2000 nitrate levels exceeded the MCL. A supply well for the City of Turlock was closed because of nitrate concentrations (DWR 2003).

Merced Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Merced Subbasin is within the San Joaquin River HR and covers approximately 491,000 acres (767 square miles) in Merced County (Figure 4-3). Surrounding subbasins include: the Chowchilla Subbasin to the south, Turlock Subbasin to the north, and Delta-Mendota Subbasin to the west. Crystalline bedrock of the Sierra Nevada lies to the east.

Water-bearing units within the subbasin consist of consolidated rock and unconsolidated deposits. The consolidated units include the Tertiary-age Ione, Valley Springs, and Mehrten Formations. Most of the consolidated material lies in the eastern portion of the subbasin and yield little water with the exception of the Mehrten Formation. The Mehrten Formation is composed of sandstone, breccia, conglomerate, tuff siltstone, and claystone.

The unconsolidated deposits are Pliocene and younger in age and from oldest to youngest include: continental deposits, lacustrine and marsh deposits, older alluvium, younger alluvium, and flood basin deposits. Among the unconsolidated units, the main water yielding units are the continental and older alluvium deposits. The lacustrine and marsh deposits, including the Corcoran Clay and the flood basin deposits yield little water while the younger alluvium generally yields moderate quantities of water.

An unconfined aquifer occurs in the unconsolidated materials above and to the east of the Corcoran Clay. The Corcoran Clay occurs in the western half of the subbasin at depths ranging from 50 to 200 feet, with the exception of the western and southern areas where clay lenses occur producing semiconfined conditions.

Annual groundwater extraction is estimated at 54,000 acre-feet for urban use and 492,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary sources of groundwater recharge in the subbasin are from deep percolation of applied irrigation water and from canals and water storage facilities. Lesser groundwater recharge occurs from percolation from small streams, direct percolation of precipitation, and underflow channels from the east. Natural recharge is estimated at 47,000 acre-feet annually while recharge of applied water is estimated at 243,000 acre-feet annually. (DWR 2003.)

Land Use

Land use within the approximate 491,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-111.

Table 4-111. Land Use in the Merced Subbasin

Land Use	Approximate Acreage
Agriculture	
Rice	3,500
Deciduous Fruits and Nuts	67,500
Field Crops	66,000
Grain and Hay	17,000
Pasture	61,500
Truck, Nursery, and Berry Crops	28,000
Vineyards	7,500
Total	**251,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition in the subbasin is the East San Joaquin River Water Quality Coalition.

Public water agencies within the Merced Subbasin include: Merced ID, Merquin County WD, Turner Island WD, Le Grand-Athlone WD, Plainsburg ID, and Stevinson WD.

The only identified major urban area in the subbasin is the City of Merced.

There are no known groundwater ordinances or regulations in Merced County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 1,230 wells in Merced County for analysis of pesticides. Groundwater samples from 25 of the wells had verified detections and 72 of the wells had unverified detection of pesticides. Detected pesticides included ACET, atrazine, bentazon, diuron, bromacil, DACT, DEA, norflurazon, prometon, and simazine (Schuette et al. 2003). In samples collected between 1994 and 2000 pesticides were detected in groundwater from eight of 62 public supply wells at concentrations greater than an applicable MCLs (DWR 2003).

Inorganic Constituents

Groundwater is typically of sodium bicarbonate type in western areas of the subbasin, calcium-magnesium bicarbonate type in interior areas of the subbasin, and calcium-sodium bicarbonate type in southern areas of the subbasin. Small areas of chloride type waters occur in the southwestern corner of the subbasin. TDS ranges from 100 to 3,600 mg/L, but usually ranges from 200 to 400 mg/L. Groundwater samples collected from 46 wells regulated by CDPH had TDS concentrations from 150 to 424 mg/L, with an average of 231 mg/L. (DWR 2003.)

Localized areas of the subbasin have groundwater with concentrations of iron, nitrates, and chlorides that impair the beneficial uses. Two of 64 public supply wells sampled from 1994 and 2000, had nitrate levels exceeding the MCL (DWR 2003).

Delta-Mendota Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The Delta-Mendota Subbasin is within the San Joaquin River HR and covers approximately 747,000 acres (1,170 square miles) in Stanislaus, Merced, Madera, and Fresno counties (Figure 4-3). The Delta-Modesto Subbasin is bounded on the west by the Tertiary and older marine sediments of the Coast Ranges, on the north by the Tracy Subbasin, on the south by the Westside Subbasin, and on the east by the Modesto, Turlock, Merced, Chowchilla, Madera, and Kings subbasins.

The water-bearing units include: the Tulare Formation, terrace deposits, alluvium, and flood basin deposits. The Tulare Formation is comprised of interbedded tongues and lenses of clay, sand, and gravel that were deposited in alternating oxidizing and reducing environments. A member of the Tulare Formation, the Corcoran Clay, is an aquitard that occurs at a depth ranging from 100 to 500 feet and acts as the confining layer that separates the underlying confined from the overlying unconfined aquifers.

Pleistocene terrace deposits of yellow, tan, and light-to-dark brown silt, sand, and gravel are elevated above present day streambeds. These deposits typically occur above the water table, but their coarse grain size makes them potential recharge areas. The alluvium consists of poorly to well-sorted clay, silt, sand, and gravel. Capping the other units of the subbasin are flood basin deposits, which are dark to light brown and gray clay, silt, sand, and organic materials.

The water-bearing zones of the Delta-Mendota Subbasin have lower, upper, and shallow zones. The lower zone is the lower section of the Tulare Formation. The upper zone is generally confined, semiconfined, and unconfined water in the upper section of the Tulare Formation and some younger deposits. The shallow zone is unconfined within 25 feet of the land surface.

Annual groundwater extraction is estimated at 17,000 acre-feet for urban use and 491,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary sources of groundwater recharge in the subbasin are from deep percolation of applied irrigation water and from canals and water storage facilities. Lesser groundwater recharge occurs from percolation from small streams and direct percolation of precipitation. Natural recharge is estimated at 8,000 acre-feet annually while recharge of applied water is estimated at 74,000 acre-feet annually.

Land Use

Land use within the approximate 747,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-112.

Table 4-112. Land Use in the Delta-Mendota Subbasin

Land Use	Approximate Acreage
Agriculture	
Rice	8,000
Deciduous Fruits and Nuts	52,500
Field Crops	207,500
Grain and Hay	18,500
Pasture	104,500
Truck, Nursery, and Berry Crops	81,500
Vineyards	2,500
Total	**475,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The identified water quality coalition within the subbasin is the Westside Water Quality Coalition.

Public water agencies within the Delta-Mendota Groundwater Subbasin include: Merced County, Fresno County, Broadview WD, Centinella WD, Central California ID, Davis WD, Del Puerto WD, Eagle Field WD, El Solyo WD, Farmers WD, Firebaugh Canal WD, Foothill WD, Fresno Slough WD, Grasslands WD, Hospital WD, Kern Canon WD, Laguna WD, Mercy Springs WD, Mustang WD, Oak Flat WD, Orestimba WD, Oro Loma WD, Pacheco WD, Panoche WD, Patterson WD, Romero WD, Salado WD, San Luis Canal Company, San Luis WD, Santa Nella CWD, Sunflower WD, Tranquility ID, West Stanislaus ID, Widren WD, and Quinto WD.

There are no identified major urban areas within the subbasin.

Pertinent ordinances and regulations affecting groundwater in the subbasin are listed below.

- Fresno County has a Groundwater Management Ordinance restricting the extraction and transfer of groundwater outside of the County.
- A County-issued permit is required for groundwater transfer, directly or indirectly, outside of the County, unless the action is exempted or a permit first obtained.
- Madera County has a Groundwater Management Ordinance that regulates the importation of foreign water for groundwater banking and exportation of groundwater outside Madera County.

No known groundwater ordinances have been adopted by Stanislaus or Merced Counties.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in Stanislaus County, 1,230 wells in Merced County, 391 wells in Madera County, and 4,032 wells in Fresno County for analysis of pesticides. In Stanislaus County, groundwater samples from 45 of the wells had verified detections and 171 of the wells had unverified detections. In Merced County, groundwater samples from 25 of the wells had verified detections and 72 of the wells had unverified detections. In Madera County, groundwater samples from 11 of the wells had verified detections and 89 of the wells had unverified detections. In Fresno County, groundwater samples from 224 of the wells had verified detections and 369 of the wells had unverified detections. ACET, atrazine, bromacil, DACT, DEA, diuron, and simazine were detected in each of the counties. Norflurazon was detected in Fresno and Merced counties (Schuette et al. 2003). Groundwater samples collected from 47 public supply wells within the subbasin (1994-2000) were analyzed for pesticides. Pesticides were detected in groundwater from one well at concentrations greater than the MCL (DWR 2003).

Inorganic Constituents

Groundwater in the subbasin is typically a mixed sulfate to bicarbonate type water. In the central and southern portions of the subbasin, areas of sodium chloride and sodium sulfate type groundwater exist. TDS concentrations range from 400 to 1,600 mg/L in the northern part of the subbasin and 730 to 6,000 mg/L in the southern part. Analysis of groundwater samples collected from 44 wells regulated by CDPH had detected TDS concentrations from 210 to 1,750 mg/L, with an average of 770 mg/L (DWR 2003).

Localized areas of the subbasin have groundwater with concentrations of iron, fluoride, nitrate, and boron that impair the beneficial uses. Analysis of groundwater samples collected from 51 wells regulated by CDPH between 1994 and 2000, detected nitrate in groundwater from 4 of the wells at concentrations exceeding the MCL (DWR 2003).

Chowchilla Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Chowchilla Subbasin is within the San Joaquin River HR and covers approximately 159,000 acres (248 square miles) in Madera and Merced counties (Figure 4-3). The subbasin is bordered to the north by the Merced Subbasin, to the southeast by Madera Subbasin and to the west by Delta-Mendota Subbasin. Crystalline bedrock of the Sierra Nevada comprises the subbasin's eastern boundary.

The major water-bearing units within the Chowchilla Subbasin are unconsolidated continental deposits of Tertiary and Quaternary age. Quaternary age deposits include older alluvium, lacustrine and marsh deposits, and younger alluvium that crop out over most of the subbasin and yield 95% of the well water. The most important source of water is the older alluvium, which is characterized as being intercalated lenses of clay, silt, sand, and some gravel. The Corcoran Clay or E-Clay underlies most of the basin at depths between 50 and 250 feet and restricts the vertical movement of water.

Annual groundwater extraction is estimated at 6,000 acre-feet for urban use and 249,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary source of groundwater recharge in the subbasin is from deep percolation of applied irrigation water. Lesser groundwater recharge occurs from percolation from streams and direct percolation of precipitation. Natural recharge is estimated at 87,000 acre-feet annually while recharge of applied water is estimated at 179,000 acre-feet annually. (DWR 2003.)

Land Use

Land use within the approximate 159,000-acre subbasin is shown on Figure 4-5. Primary crops grown, and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-113.

Table 4-113. Land Use in the Chowchilla Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	29,000
Field Crops	40,500
Grain and Hay	8,000
Pasture	38,000
Truck, Nursery, and Berry Crops	1,000
Vineyards	12,500
Total	**129,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the subbasin is the East San Joaquin River Water Quality Coalition.

Public water agencies include: Chowchilla WD, Clayton WD, El Nido ID, New Stone WD, and Sierra WD (inactive). California Water Service Company is the only identified private water agency in the subbasin.

Madera County has adopted an ordinance to provide regulatory control over the exporting groundwater, groundwater banking, and importing groundwater for groundwater banking. There are no known pertinent groundwater regulations in Merced County.

There are no identified urban areas within the subbasin.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 1,230 wells in Merced County and 391 wells in Madera County for analysis of pesticides. In Merced County, groundwater samples from 25 of the wells had verified detections and 72 of the wells had unverified detections. In Madera County, groundwater samples from 11 of the wells had verified detections and

89 of the wells had unverified detections. ACET, atrazine, bromacil, DACT, DEA, diuron, and simazine were detected in both counties. Norflurazon was detected in Merced County (Schuette et al. 2003). Groundwater samples collected from 12 water supply wells regulated by CDPH within the subbasin from 1994 through 2000 were analyzed for pesticides. Pesticides were not detected in groundwater from any of these wells at a concentration greater than an applicable MCL (DWR 2003).

Inorganic Constituents

Groundwater in the subbasin is typically a calcium-sodium bicarbonate type water in the eastern part of the subbasin and grades to a calcium bicarbonate, sodium-calcium bicarbonate, and sodium chloride type waters towards the western portion of the subbasin. TDS concentrations range from 120 to 6,400 mg/L, but are typically in a range from 200 to 500 mg/L. Analysis of groundwater samples collected from 8 wells regulated by CDPH had TDS concentrations from 120 to 390 mg/L, with an average TDS concentration of 228 mg/L. (DWR 2003.)

Localized areas of the subbasin have groundwater with concentrations of iron, nitrate, and chloride that impair the beneficial uses. None of the 10 public supply wells sampled between 1994 and 2000 had nitrate levels exceeding the MCL (DWR 2003).

Madera Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Madera Subbasin is within the San Joaquin River HR and covers approximately 394,000 acres (614 square miles) in Madera County (Figure 4-3). The Madera Subbasin is bounded to the east by crystalline bedrock of the Sierra Nevada, to the south by the Kings Subbasin, the Delta-Mendota Subbasin to the west, and the Chowchilla Subbasin to the north.

The water-bearing units in the Madera Subbasin consist of unconsolidated Pleistocene and Holocene age deposits. Quaternary continental deposits include older and younger alluvium, lacustrine, and marsh deposits that crop out over most of the Madera Subbasin and probably yield 95% of the well water. The most important part of the Quaternary deposits is the older alluvium. The older alluvium consists of intercalated lenses of clay, silt, sand, and some gravel. Within the older alluvium are lacustrine and marsh deposits that contain the E-Clay. The E-Clay does not crop out, but occurs at depths between 150 and 300 feet and restricts vertical movement of water.

Older Continental deposits of Tertiary and Quaternary, which include the Ione Formation, crop out along the subbasin's eastern margin and may yield small quantities of water.

Major Sources of Recharge

The primary source of groundwater recharge in the subbasin is from deep percolation of applied irrigation water. Lesser groundwater recharge occurs from percolation from streams and direct percolation of precipitation. Natural recharge is estimated at 21,000 acre-feet annually while recharge of applied water is estimated at 404,000 acre-feet annually. Annual groundwater extraction is estimated at 15,000 acre-feet for urban use and 551,000 acre-feet for agricultural use (DWR 2003).

Land Use

Land use within the approximate 394,000-acre subbasin is shown on Figure 4-5. Primary crops grown, and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-114.

Table 4-114. Land Use in the Madera Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	7,000
Deciduous Fruits and Nuts	81,000
Field Crops	21,500
Grain and Hay	16,000
Pasture	16,500
Truck, Nursery, and Berry Crops	2,500
Vineyards	97,500
Total	**242,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the subbasin is the East San Joaquin River Water Quality Coalition.

Public water agencies within the Madera Groundwater Subbasin include: Gravelly Ford WD, Madera ID, and Root Creek WD. There are no known private water agencies within the subbasin.

The largest urban area within the subbasin is the City of Madera with a population of approximately 46,000 people.

Madera County has adopted an ordinance to provide regulatory control over exporting of groundwater, groundwater banking, and importing of groundwater for groundwater banking.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 391 wells in Madera County for analysis of pesticides. Groundwater samples from 11 of the wells had verified detections and 89 of the wells had unverified detections. Detected pesticides include: ACET, atrazine, bromacil, DACT, DEA, diuron, and simazine (Schuette et al. 2003). Groundwater samples collected from 46 water supply wells within the subbasin from 1994 through 2000 were analyzed for pesticides. Pesticides were detected in groundwater samples from 3 of the wells at a concentration greater than an applicable MCL (DWR 2003).

Inorganic Constituents

Groundwater in the subbasin is typically a calcium-sodium bicarbonate type water with sodium bicarbonate and sodium chloride type waters along the western margin of the subbasin. TDS ranges from 100 to 6,400 mg/L, but are typically in a range from 200 to 400 mg/L. Analysis of groundwater samples collected from 40 wells regulated by CDPH had TDS concentrations from 100 to 400 mg/L, with an average TDS concentration of 251 mg/L (DWR 2003).

Localized areas of the subbasin have groundwater with concentrations of iron, nitrate, and chloride that impair the beneficial uses. One of 43 public supply wells sampled between 1994 and 2000, had nitrate levels exceeding the MCL (DWR 2003).

SAN JOAQUIN VALLEY GROUNDWATER BASIN—TULARE LAKE HYDROLOGIC REGION SUBBASINS

Westside Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Westside Subbasin is within the Tulare Lake HR and comprises an area of approximately 640,000 acres (1,000 square miles) located in the western portion of Fresno County and the northwestern portion of Kings County (Figure 4-4). The subbasin is bordered on the southwest by the Pleasant Valley Subbasin, the north and northeast by the Delta-Mendota Subbasin, the east by the Kings Subbasin, the southeast by the Tulare Lake Subbasin, and on the west by Tertiary marine sediments of the Coast Ranges.

The water-bearing units comprising the Westside Subbasin consist of unconsolidated continental deposits of Tertiary and Quaternary age. These deposits form an unconfined to semiconfined upper aquifer and a confined lower aquifer. These aquifers are separated by the Corcoran Clay (E-Clay) member of the Tulare Formation . The depth to the top of the Corcoran Clay varies from approximately 500 to 850 feet (DWR 1981).

The unconfined to semiconfined aquifer (upper zone) above the Corcoran Clay includes younger alluvium, older alluvium, and the upper part of the Tulare Formation. These deposits consist of lenticular, poorly sorted clay, silt, and sand intercalated with occasional beds of well-sorted fine to medium grained sand.

The confined aquifer (lower zone) consists of the lower part of the Tulare Formation and possibly the uppermost part of the San Joaquin Formation. This unit is composed of lenticular beds of silty clay, clay, silt, and sand interbedded with occasional strata of well-sorted sand. Brackish or saline water underlies the usable groundwater in the lower zone.

Fine-grained flood basin deposits along the east side of the subbasin restrict the downward movement of percolating water. In certain areas this causes percolation of applied water to buildup as shallow water (perched) in the near surface zone. This shallow groundwater is typically of poor quality and is not a significant source of produced groundwater.

The Corcoran Clay is a lacustrine diatomaceous clay unit that underlies much of the sub basin. Within the subbasin it varies in thickness from 20 to 120 feet. Prior to groundwater development, the Corcoran Clay effectively separated the upper and lower zones. Numerous wells penetrate the clay and have allowed partial interaction between the zones.

Major Sources of Recharge

The main source of recharge to the subbasin aquifer system is from the seepage of Coast Range streams along the west side of the subbasin and deep percolation of surface irrigation. Recharge to the lower aquifer occurs by subsurface flow from areas to the east and northeast. (DWR 2003.)

Seepage from west side streams was estimated to amount to 30,000-40,000 acre-feet per year. For 1951, secondary recharge from the east into the upper aquifer was 20,000–30,000 acre-feet and was 150,000–200,000 acre-feet into the lower aquifer (DWR 2003).

Westlands WD (Westlands) estimated that the average deep percolation between 1978 and 1996 was 244,000 acre-feet per year. Westlands also estimated that the average applied groundwater between 1978 and 1997 was 193,000 acre-feet per year (DWR 2003).

Land Use

Land use within the approximate 744,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-115.

Table 4-115. Land Use in the Westside Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	1,000
Deciduous Fruits and Nuts	56,500
Field Crops	321,000
Grain and Hay	46,000
Pasture	31,000
Truck, Nursery, and Berry Crops	174,000
Vineyards	12,500
Total	**642,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The WestlandsWater Quality Coalition is the only identified water quality coalition within the subbasin.

Westlands WD is the only identified public water agency within the Westside Subbasin. There are no identified private water agencies within the subbasin.

There are no identified major urban areas in the subbasin.

Pertinent ordinances and regulations affecting the Westside Subbasin are as follows:

- AB 3030, California Groundwater Management Plan, adopted in 1992.

- Fresno County has a Groundwater Management Ordinance restricting the extraction and transfer of groundwater outside of the County.
- A County-issued permit is required for groundwater transfer, directly or indirectly, outside of the County, unless the action is exempted or a permit first obtained.

No known pertinent groundwater ordinances have been adopted by Kings County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR (Schuette et al. 2003) reports that between 1986 and 2003, 4,032 wells were sampled for pesticide residues in Fresno County and 229 wells were sampled in Kings County, both of which comprise portions of the Westside Subbasin. Fresno County had 224 wells with verified detections 369 wells with unverified detections while Kings County reported 4 wells with verified detections and 6 wells with unverified detections. Fresno County detections included ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine. Kings County had detections of atrizine, diuron, and prometon.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed to be the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater beneath the west side of the San Joaquin Valley is typically a sulfate or bicarbonate type water. Water quality of the upper aquifer is typically high in calcium and magnesium sulfate. Groundwater below 300 feet and above the Corcoran Clay shows a tendency of decreased dissolved solids with increased depth. Most of the groundwater in the lower aquifer is a sodium-sulfate type water (DWR 2003).

Based on the analysis of groundwater samples collected from six wells regulated by CDPH, the average TDS of the subbasin is 520 mg/L with a range from 220 mg/L to 1,300 mg/L. However, TDS concentrations in shallow groundwater can be greater than 10,000 mg/L at some locations in the lower fan areas of the subbasin with one sample having a TDS concentration of 35,000 mg/L. Groundwater in western Fresno County has an upper TDS concentration ranging from 2,000 to 3,000 mg/L. (DWR 2003.)

High TDS impairs groundwater use in the subbasin. Groundwater at certain locations also contains selenium and boron that may affect beneficial uses.

Bulletin 118 (DWR 2003) indicates that groundwater samples from 2 wells were analyzed for nitrates and detected concentrations were less than the MCL.

Kings Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The Kings Subbasin is within the Tulare Lake HR and comprises an area of approximately 976,000 acres (1,530 square miles) primarily within Fresno County with the southern portion of the subbasin in Kings and Tulare Counties (Figure 4-4). The Kings Subbasin is bounded on the north by the Madera Subbasin, on the south by the Kaweah and Tulare Lake subbasins, and on the west by the Westside and Delta-Mendota Subbasins. Bedrock of the Sierra Nevada foothills bounds the subbasin on the east.

The water-bearing units of the Kings Subbasin consist of unconsolidated continental deposits. These deposits include an older series of Tertiary and Quaternary age sediments overlain by a younger series of Quaternary age sediments. The Quaternary age deposits are divided into older alluvium, lacustrine and marsh deposits, younger alluvium, and flood basin deposits.

The older alluvium consists of intercalated lenses of clay, silt, silty and sandy clay, clayey and silty sand, sand, gravel, cobbles, and boulders. It is, generally, fine grained near the trough of the valley. Lacustrine and marsh deposits are interbedded with the older alluvium in the western portion of the subbasin.

The younger alluvium consists of fluvial deposits of arkosic composition that overlie the older alluvium and are interbedded with the flood basin deposits. Its lithology is similar to the underlying older alluvium. Beneath river channels, the younger alluvium is highly permeable with lesser permeability beneath flood basin deposits. The flood basin deposits occur along the Fresno Slough and James Bypass. They consist of sand, silt, and clay.

The deposits of Quaternary age are exposed over most of the area and yield more than 90% of the water pumped from wells. The older continental deposits are exposed in the southeastern part of the subbasin and yield small amounts of water to wells.

Flood basin deposits provide minimal amounts of water to wells and typically restrict the flow of groundwater. The Corcoran Clay member of the Tulare Formation is the most extensive of these deposits. The Corcoran Clay lies at a depth 250 to 550 feet in the western one quarter to one third of the subbasin.

Major Sources of Recharge

Groundwater recharge occurs from river and stream seepage, deep percolation of irrigation water, canal seepage, and intentional recharge. The Cities of Fresno and Clovis, Fresno ID, and Fresno Metropolitan Flood Control District have a cooperative effort to utilize individually owned facilities to recharge surplus surface water in the greater urban area. Fresno ID, Consolidated ID, and others have similar groundwater recharge efforts in the subbasin. The Fresno-Clovis metropolitan area uses a regional sewage treatment facility that percolates treated wastewater in ponds southwest of Fresno (DWR 2003). The percolation of treated wastewater has created a significant groundwater mound beneath the facility.

Groundwater flow is generally to the southwest. The potential exists for subsurface flows to the south and west. Depending upon local groundwater conditions in the Westside Subbasin, subsurface flows may occur in that direction. The potential exists for groundwater flow in either direction along the southern boundary of the subbasin. Groundwater depressions on either side of the subbasin boundary and groundwater mounding from recharge along the Kings River complicate flow patterns in the area (DWR 2003).

Land Use

Land use within the approximately 976,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-116.

Table 4-116. Land Use in the Kings Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	52,500
Deciduous Fruits and Nuts	168,500
Field Crops	133,500
Grain and Hay	24,000
Pasture	78,000
Vineyards	263,000
Total	**719,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Kings Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water agencies within the Kings Subbasin include: City of Fresno, City of Clovis, Alta ID, Consolidated ID, Fresno ID, Hills Valley ID, James ID, Kings River Conservation District (KRCD), Kings River WD, Laguna ID, Liberty WD, Mid-Valley WD, Orange Cove ID, Raisin City ID, Riverdale ID, and Tri-Valley ID. Identified private water agencies within the subbasin are California Water Service Company and Bakman Water Company.

Major urban areas include the Fresno-Clovis metropolitan area with a population in excess of 500,000.

Pertinent ordinances and regulations affecting the Kings Subbasin are as follows:

- Alta ID, Consolidated ID, County of Fresno, Fresno ID, James ID, KRCD, Kings River WD, Liberty Canal Company, Liberty WD, Liberty Mill Race Company, Mid Valley WD, Orange Cove ID, Raisin City WD, and Riverdale ID have adopted AB 3030 Groundwater Management Plans.
- Fresno County has a Groundwater Management Ordinance restricting the extraction and transfer of groundwater outside of the County.

A County-issued permit is required for groundwater transfer, directly or indirectly, outside of the County, unless the action is exempted.+ No known pertinent groundwater ordinances have been adopted by Kings or Tulare Counties.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR (Schuette et al. 2003) reported that between 1986 and 2003, 4,032 wells were sampled for pesticide residues in Fresno County, 229 wells in Kings County, and 1,547 wells in Tulare County, all three of which comprise portions of the Kings subbasin. Fresno County had 224 wells with verified detections and 369 wells with unverified detections, Kings County reported 4 wells with verified detections and 6 wells with unverified detections, and Tulare County reported 365 wells with verified detections and 256 wells with unverified detections. Groundwater detections in Fresno and Tulare County included: ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine. Groundwater detections in Kings County included: atrizine, diuron, and prometon.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and were not reviewed by DPR (Schuette et al. 2003). DBCP, a soil fumigant (nematicide), has been detected in groundwater along the eastern side of the subbasin (DWR 2003).

Inorganic Constituents

The groundwater in the Kings Subbasin is predominantly a bicarbonate type water. The major cations are calcium, magnesium, and sodium. Sodium appears higher in the western portion of the subbasin where some chloride waters are also found (DWR 2003).

The TDS of groundwater in the Fresno area seldom exceeds 600 mg/L although 2,000 mg/L groundwater has been encountered at greater depths. A typical range of TDS concentrations in groundwater in the subbasin is 200 to 700 mg/L. CDPH data indicates an average TDS concentration of 240 mg/L in 414 samples collected from water supply wells subject to Title 22 regulations. The detected TDS concentrations of these samples ranged from 40 to 570 mg/L. (DWR 2003.)

Analysis of groundwater samples collected from 463 wells detected nitrates at concentrations greater than the MCL in 23 of the wells.

Shallow brackish groundwater can be found in localized areas along the western portion of the subbasin. This shallow water contains elevated concentrations of fluoride, boron, and sodium (DWR 2003).

Tulare Lake Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Tulare Lake Subbasin is within the Tulare Lake HR and comprises an area of 524,000 acres (818 square miles) primarily located in Kings County with a small portion along the eastern boundary of the subbasin within Tulare County (Figure 4-4). The Tulare Lake Subbasin is bordered on the north by the Kings Subbasin, on the northwest by the Westside Subbasin, to the east by the Kaweah and Tule Subbasins, and to the south by the Kern Subbasin. Tertiary marine sediments of the Kettleman Hills border the subbasin on the southwest.

Sediments comprising the Tulare Lake Subbasin include younger and older alluvium, flood basin deposits, lacustrine and marsh deposits, and continental deposits. Younger alluvium is a heterogeneous complex of interstratified discontinuous beds of unsorted to fairly well sorted clay, silt, sand, and gravel. This unit is very permeable but largely above the water table. Older alluvium consists of poorly sorted lenticular deposits of clay, silt, sand, and gravel, which may be loosely consolidated to cemented. Older alluvium is moderately to highly permeable and yields large quantities of water to wells. The unit is a major aquifer in the subbasin. Flood basin deposits are relatively impermeable silt and clay with some moderately to poorly permeable sand layers. This unit is not an important source of groundwater, but locally, may yield sufficient supplies for domestic and stock use. Lacustrine and marsh deposits are reduced deposits of silt, clay, and fine sand. In the subsurface, lacustrine clay interfingers with continental and alluvial deposits. The lacustrine and marsh deposits include the Corcoran Clay that underlies the sub basin at depths ranging between about 300 and 900 feet (DWR 1981). Continental deposits consist of poorly sorted lenticular deposits of clay, silt, sand, and gravel. These deposits are moderately to poorly permeable and yield low to large quantities of water to wells (DWR 2003).

Major Sources of Recharge

Groundwater recharge is primarily from percolation along stream channels and deep percolation of applied irrigation water. Natural recharge within the subbasin is estimated to be 89,200 acre-feet per year with recharge of applied water estimated to be 195,000 acre-feet per year. Annual urban and agricultural extractions are estimated at 24,000 and 648,000 acre-feet, respectively. (DWR 2003.)

Land Use

Land use within the approximate 524,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-117.

Table 4-117. Land Use in the Tulare Lake Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	35,500
Field Crops	214,000
Grain and Hay	64,000
Pasture	55,500
Truck, Nursery, and Berry Crops	16,000
Vineyards	5,000
Total	**390,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Tulare Lake Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water agencies in the Tulare Lake Groundwater Subbasin include: Alpaugh ID, Angiola WD, Atwell Island WD, Delano-Earlimart ID, Ducor ID, Kern-Tulare WD, Lower Tule River ID, Pixley ID, Porterville ID, Rag Gulch ID, Saucelito ID, Teapot Dome WD, Terra Bella ID, and Vandalia ID. California Water Service is the only identified private water agency within the subbasin.

The largest urban within the subbasin area is the City of Hanford with a population of approximately 46,350.

No known pertinent ordinances or regulations affect groundwater in the Tulare Lake Subbasin.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR reports that between 1986 and 2003, 229 wells were sampled for pesticide residues in Kings County. Four of those wells had verified detections and 6 of the wells had unverified detections of atrizine, diuron, and/or prometon (Schuette et al. 2003). DWR (2003) reported detection of pesticides at concentration greater than an applicable MCL in groundwater collected from 2 of 40 wells sampled.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater within the Tulare Lake Subbasin is generally a calcium bicarbonate type water in the northern portion that trends toward a sodium bicarbonate type water beneath Tulare Lakebed. Detected TDS concentrations typically range from 200 to 600 mg/L. TDS concentrations of shallow groundwater in areas of poor drainage are as high as 40,000 mg/L. CDPH reported that detected TDS concentrations in groundwater collected from 36 wells (subject to Title 22 water quality standards) ranged from 150 to 820 mg/L, with an average of 342 mg/L. The city of Hanford reported that EC values in groundwater from 14 wells ranged from 210 to 820 micromhos per centimeter (µmhos/cm), with an average value of 554 µmhos/cm. (DWR 2003.)

From 1994 to 2000, groundwater samples were collected from 38 wells within the subbasin for analysis of nitrates. Nitrates were not detected at a concentration above the MCL in any of the samples (DWR 2003).

There are areas of saline shallow groundwater in the southern portion of the subbasin and localized areas of high arsenic. The City of Hanford reported odors caused by the presence of hydrogen sulfide (DWR 2003).

Kaweah Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The Kaweah Subbasin is within the Tulare Lake HR and comprises an area of approximately 446,000 acres (696 square miles) primarily in Tulare County with a small portion in Kings County (Figure 4-4). The Kaweah Subbasin is bounded on the north by the Kings Subbasin, on the south by the Tule Subbasin, and on the west by the Tulare Lake Subbasin, and on the east by crystalline bedrock of the Sierra Nevada foothills.

The Kaweah Subbasin aquifers are composed of unconsolidated sediments of Pliocene, Pleistocene, and Holocene age. On the east side of the subbasin, these deposits consist of arkosic material derived from the Sierra Nevada and are divided into three stratigraphic units: continental deposits, older alluvium, and younger alluvium. In the western portion of the subbasin unconsolidated deposits consisting of flood basin and lacustrine and marsh deposits interfinger with the eastside deposits.

The continental deposits of Pliocene and Pleistocene age are divided into oxidized and reduced deposits based on depositional environment. The oxidized deposits crop out along the eastern margin of the valley and consist of deeply weathered, poorly permeable, reddish-brown sandy silt and clay with well-developed soil profiles. The reduced deposits are moderately permeable and consist of micaceous sand, silt, and clay that extend to the west side of the valley in the subsurface.

Older alluvium, which overlies the continental deposits, is moderately to highly permeable and is the major aquifer in the subbasin. Younger alluvium consists of moderately to highly permeable arkosic sand and silty sand. Flood basin deposits consist of poorly permeable silt, clay, and fine sand. Groundwater in the flood basin deposits is often of poor quality. Lacustrine and marsh deposits consist of blue, green, or gray silty clay and fine sand and underlie the flood basin deposits. Clay beds of the lacustrine and marsh deposits form aquitards that control the vertical and lateral movement of groundwater. The most prominent lacustrine deposit is the Corcoran Clay that underlies the western half of the Kaweah Subbasin at depths ranging from about 200 to 500 feet (DWR 1981). The Corcoran Clay separates the lower confined from the upper unconfined aquifers where present. In the eastern portion of the subbasin (areas where the Corcoran Clay is absent), groundwater occurs under unconfined and semi-confined conditions (DWR 2003).

Major Sources of Recharge

The primary source of recharge to the area is seepage from streams flowing from the Sierra Nevada and percolation of applied irrigation water. Natural recharge is estimated to be 62,400 acre-feet per year. Lakeside Irrigation District has recharged about 7,000 acre-feet per year and in wet years may recharge up to 30,000 acre-feet. It is estimated that approximately 286,000 acre-feet of applied water is recharged annually in the subbasin. Annual urban and agricultural extraction is estimated to be 58,800 and 699,000 acre-feet, respectively. (DWR 2003.)

Groundwater flow is generally southwestward. Subsurface outflow may occur to the west and south towards the Tulare Lake Subbasin. DWR (2003) has not estimated the amount of inflow or outflow for the subbasin.

Land Use

Land use within the approximate 446,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-118.

Table 4-118. Land Use in the Kaweah Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	77,000
Deciduous Fruits and Nuts	60,000
Field Crops	160,000
Grain and Hay	19,000
Pasture	57,500
Truck, Nursery, and Berry Crops	6,500
Vineyards	13,000
Total	**393,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Kaweah Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water entities within the Kaweah Groundwater Subbasin include: Exeter ID, Ivanhoe ID, Kaweah-Delta WCD, Kings River Conservation District, Lakeside Irrigation Water District, Lindmore ID, Lindsay-Strathmore ID, St. Johns WD, Tulare ID, and Stone Corral WD. Private water entities within the subbasin include California Water Service, Melga Canal Company, Settlers Ditch Company, and Corcoran Irrigation Company.

Identified major urban areas are the City of Visalia with a population of approximately 92,500 and the City of Tulare with a population of approximately 49,500.

No known pertinent ordinances or regulations affect groundwater in the Kaweah Subbasin.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR reports that from 1986 to 2003, groundwater samples were collected from 1,547 wells in Tulare County and 229 wells in Kings County and analyzed for pesticide residues. Groundwater samples from 365 of the wells had verified detections of pesticides and groundwater samples from 256 of the wells had unverified detection of pesticides in Tulare County. In Kings County, verified detections of pesticides were reported in samples collected from 4 wells with unverified detections reported in samples collected from 6 wells. The detections in Tulare County were ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine. Detections in Tulare County included atrazine, diuron, and prometon (Schuette et al. 2003). DWR reported that from 1994 to 2000, groundwater samples were collected from 167 well regulated; by CDPH and analyzed for pesticides. Pesticides were detected at concentrations greater than applicable MCLs in 16 of the wells.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater in the Kaweah Subbasin is typically a calcium bicarbonate type water, with sodium-bicarbonate type water near the western margin of the subbasin. TDS ranges from 35 to 1,000 mg/L, with a typical range of 300 to 600 mg/L. The CDPH reported TDS concentrations in groundwater collected from 153 wellsranged from 35 to 580 mg/L, with an average concentration of 189 mg/L. (DWR 2003.)

DWR (2003) reports that there are localized areas of high nitrate concentrations in groundwater on the eastern side of the subbasin and an area of high salinity groundwater between Lindsay and Exeter.

Tule Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The Tule Subbasin is within the Tulare Lake HR and comprises an area of approximately 467,000 acres (733 square miles) in Tulare County (Figure 4-4). The subbasin is generally bordered on the north by the Kaweah Subbasin, on the south by the Kern Subbasin, on the west by the Tulare Lake Subbasin, and on the east by crystalline bedrock of the Sierra Nevada foothills.

The sediments that comprise the subbasin's aquifer are continental deposits of Tertiary and Quaternary age (Pliocene to Holocene). These deposits include flood basin deposits, younger alluvium, older alluvium, the Tulare Formation, and undifferentiated continental deposits. Flood basin deposits consist of relatively impermeable silt and clay interbedded with some moderately to poorly permeable sand layers that interfinger with the younger alluvium. These deposits are not an important source of water to wells, but may yield sufficient supplies for domestic and stock use. The younger alluvium consists of interstratified and discontinuous beds of unsorted to fairly well sorted clay, silt, sand, and gravel beneath the alluvial fans in the valley and stream channels. Where saturated, the younger alluvium is very permeable, but this unit is largely unsaturated and probably not important as a source of water. The older alluvium consists of poorly sorted deposits of clay, silt, sand, and gravel. This unit is moderately to highly permeable and is a major source of water to wells.

The Tulare Formation consists of poorly sorted deposits of clay, silt, sand, and gravel derived predominately from the Coast Ranges. It contains the Corcoran Clay Member, a major confining bed in the subbasin. The formation is moderately to highly permeable and yields moderate to large quantities of water to wells.

The undifferentiated continental deposits consist of poorly sorted lenticular deposits of clay, silt, sand, and gravel derived from the Sierra Nevada. The unit is moderately to highly permeable and is a major source of groundwater in the subbasin. (DWR 2003.)

Major Sources of Recharge

Groundwater recharge is primarily from stream recharge and from deep percolation of applied irrigation water (Hilton et al. 1963). The natural recharge into the subbasin is estimated at 34,400 acre-feet per year. Approximately 201,000 acre-feet of recharge from applied water occurs annually in the subbasin. Annual urban and agricultural extractions are estimated to be 19,300 and 641,000 acre-feet, respectively (DWR 2003). Groundwater flow is generally westward. Recharge to the confined aquifer below the Corcoran Clay occurs as subsurface flow from the east. (DWR 2003.)

Land Use

Land use within the approximate 467,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-119.

Table 4-119. Land Use in the Tule Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	36,500
Deciduous Fruits and Nuts	38,000
Field Crops	99,000
Grain and Hay	51,000
Pasture	60,500
Truck, Nursery, and Berry Crops	2,500
Vineyards	56,500
Total	**344,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Tule Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water entities within the Tule Groundwater Sub basin include: Alpaugh ID, Angiloa WD, Atwell Island WD, Delano-Earlimart ID, Ducor ID, Kern-Tulare WD, Lower Tule River ID, Pixley ID, Porterville ID, Rag Gulch WD, Saucelito ID, Teapot Dome WD, Terra Bella ID, and Vandalia ID. California Water Service is the only identified private water entity within the subbasin.

The largest urban area in the subbasin is the City of Porterville with a population of approximately 44,500.

No known pertinent ordinances or regulations affect groundwater in the Tule Subbasin.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR reports that from 1986 to 2003, that groundwater samples were collected from 1,547 wells in Tulare County for analysis of pesticide residues. Verified detections were reported in 365 of the wells sampled with unverified detections reported in samples from 256 of the wells. The detections included:

ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine (Schuette et al. 2003). DWR (2003) reported that from 1994 to 2000, groundwater samples were collected from 73 wells regulated by the CDPH. One of those wells contained groundwater with a verified pesticide concentration above an applicable MCL.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater beneath the northern portion of the subbasin is a calcium-bicarbonate type water, while groundwater beneath the southern portion of the subbasin is typically a sodium-bicarbonate type water. Detected TDS concentrations typically range from 200 to 600 mg/L. TDS concentrations of shallow groundwater in areas of poor drainage can be as high as 30,000 mg/L. CDPH, which enforces` Title 22 water quality standards, reports TDS concentrations in groundwater (65 wells, sampled from 1994 to 2000) ranged from 20 to 490 mg/L, with an average concentration of 256 mg/L. Saline shallow groundwater occurs in the western portion of the subbasin (DWR 2003).

DWR (2003) reports that the eastern side of the subbasin has localized nitrate pollution. Six of 71 public supply wells sampled from 1994 and 2000, had nitrate levels exceeding the MCL (DWR 2003).

Kern County Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Kern County Subbasin is within the Tulare Lake HR and comprises an area of approximately 1,945,000 acres (3,040 square miles) in Kern County. The subbasin is bounded to the north by the Tulare Lake and Tule Subbasin, to the east and south by crystalline bedrock of the Sierra Nevada and San Emigdio Mountains, and to the west by the marine sediments of the San Emigdio Mountains and Coast Ranges.

The shallow to intermediate depth water-bearing units in the subbasin are primarily continental deposits of Tertiary and Quaternary age. From oldest to youngest the deposits include: the Olcese and Santa Margarita Formations, the Tulare Formation (western portion of the subbasin) and laterally equivalent Kern River Formation (eastern portion of the subbasin), older alluvium, and younger alluvium and laterally equivalent flood basin deposits (DWR 2003).

The origin of the Miocene Olcese and Santa Margarita Formations varies from continental to marine from east to west across the subbasin. The Olcese and Santa Margarita Formations are current sources of drinking water only in the northeastern portion of the sub basin where they occur as confined aquifers. The Olcese Formation is primarily sand, ranging in thickness from 100 to 450 feet. The Santa Margarita Formation is from 200 to 600 feet thick and consists of coarse-grained sand (DWR 2003).

The Tulare and Kern River Formations are both Plio-Pleistocene age and represent a west/east facies change across the subbasin. The Tulare Formation (western subbasin) contains up to 2,200 feet of interbedded, oxidized to reduced sands; gypsiferous clays and gravels derived primarily from Coast Range sources. The formation includes the Corcoran Clay, which is present in the subsurface from the Kern River Outlet Channel on the west through the central and much of the eastern subbasin at depths of 300 to 650 feet. Groundwater beneath the Corcoran Clay is confined. The Kern River Formation includes from 500 to 2,000 feet of poorly sorted, lenticular deposits of clay, silt, sand, and gravel derived from the Sierra Nevada. Both units are moderately to highly permeable and yield moderate to large quantities of water to wells (DWR 2003).

The older alluvium and Terrace Deposits are composed of up to 250 feet of Pleistocene-age lenticular deposits of clay, silt, sand, and gravel that are loosely consolidated to cemented and are exposed mainly at the subbasin margins. The unit is moderately to highly permeable and yields large quantities of water to wells. This sedimentary unit is often indistinguishable from the Tulare and Kern River Formations below and together with these underlying formations, forms the principal aquifer in the Kern County Subbasin (DWR 2003).

The Holocene-age younger alluvium and flood basin deposits vary in character and thickness in the subbasin. Along the eastern and southern subbasin margins, the unit consists of up to 150 feet of interstratified and discontinuous beds of clay, silt, sand, and gravel. In the southwestern portion of the subbasin the unit is finer grained and less permeable as it grades into fine-grained flood basin deposits underlying the historic lakebeds of Buena Vista and Kern Lakes in the southern portion of the subbasin. The flood basin deposits consist of silt, silty clay, sandy clay, and clay interbedded with poorly permeable sand layers. These flood basin deposits are difficult to distinguish from underlying fine-grained older alluvium and the total thickness of both units may be as much as 1,000 feet (DWR 2003).

Faults that affect groundwater movement include the Edison, Pond-Poso, and White Wolf faults. Other barriers to groundwater movement include anticlinal folds such as Elk Hills and Buena Vista Hills, angular unconformities, and contacts with crystalline and consolidated sedimentary rocks at the subbasin margins. The Corcoran Clay significantly impedes vertical groundwater movement where present (DWR 2003).

Major Sources of Recharge

Applied irrigation water is the largest source of recharge in the subbasin with natural recharge occurring primarily from stream seepage along the eastern margin of the subbasin and the Kern River (DWR 2003).

Water banking was initiated in the subbasin in 1978, and as of 2000, seven projects contain over 3 maf of banked water in a combined potential storage volume of 3.9 maf (KCWA 2001). Approximately two-thirds of this storage is in the Kern River Fan area west of Bakersfield with the remainder in the Arvin-Edison WSD in the southeastern portion of the subbasin and in the Semitropic WSD in the northwestern part of the subbasin.

Land Use

Land use within the approximately 1,945,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-120.

Table 4-120. Land Use in the Kern County Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	56,000
Deciduous Fruits and Nuts	198,500
Field Crops	350,500
Grain and Hay	130,500
Pasture	125,000
Truck, Nursery, and Berry Crops	91,500
Vineyards	115,500
Total	**1,067,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Kern Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water entities within the Kern County Groundwater Subbasin include: Kern County Water Agency, City of Bakersfield, West Kern Water Agency, and the Buena Vista Water agency. Private water entities within the subbasin include: California Water Service Company, McFarland Mutual Water Company, Stockdale Mutual Water Company, and numerous small community groups.

The City of Bakersfield is the only identified major urban area within the subbasin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a Conditional Use Permit (CUP) by Kern County to transport native groundwater outside of Kern County and its watersheds, including those through joint water conveyance facilities and sales to owners of water conveyance facilities. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR reports that from 1986 to 2003, groundwater samples were collected from 1,341 wells in Kern County for analysis of pesticide residues. Verified detections were reported in 22 of the wells sampled; however there were 206 unverified detections. The verified detections included ACET, atrizine, bromacil, DACT, DEA, diuron, and simazine (Schuette et al. 2003). From 1994 to 2000, 436 groundwater samples were collected from wells regulated by CDPH in Kern County. Analysis of groundwater from 23 of the wells detected at least one pesticide at a concentration greater than an applicable MCL (DWR 2003).

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater beneath the eastern portion of the Kern Subbasin contains primarily calcium bicarbonate type water in the shallow zones with the sodium content increasing with depth. In western parts of the subbasin bicarbonate is replaced by sulfate and lesser chloride. The average TDS concentration of groundwater is 400 to 450 mg/L with a range of 150 to 5,000 mg/L (DWR 2003).

Shallow groundwater near the trough of the valley has high TDS, sodium, chloride, and sulfate concentrations. Elevated arsenic concentrations exist in some areas associated with lakebed deposits. Nitrate, DBCP, and ethyl dibromide have been detected at concentrations exceeding MCLs in various areas of the basin. Groundwater samples for analysis of nitrates were collected between 1994 and 2000 from 475 wells in Kern County. Nitrates were detected at concentrations greater than the MCL in groundwater from 38 of the wells (DWR 2003).

Pleasant Valley Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Pleasant Valley Groundwater Subbasin is within the Tulare Lake HR and comprises an area of approximately 146,000 acres (227 square miles) in the western portion of Kings and Fresno Counties (Figure 4-4). The subbasin lies on the western edge of the San Joaquin Valley and is mostly surrounded by uplifted areas of the Coast Ranges and Kettleman Hills. The subbasin is bounded by the Westside Subbasin to the northeast, Tulare Lake Subbasin to the east, and Kern County Subbasin to the south.

Water-bearing units within the subbasin include Holocene alluvium, the Plio-Pleistocene Tulare Formation, and the Pliocene San Joaquin Formation. Holocene alluvium consists of lenticular deposits of poorly sorted clay, silt, and sand. It is believed that the thickness of this unit does not exceed 300 feet (DWR 2003).

The Plio-Pleistocene Tulare Formation unconformably underlies Holocene alluvium. The Tulare Formation comprises the youngest folded sediments exposed in the Kettleman Hills. In the Kettleman Hills, where the unit is exposed, it consists primarily of continental deposits of sandstone and conglomerate. DWR (2003) reports that the Tulare Formation in the subbasin consists of highly lenticular deposits of poorly sorted clay, silt, and sand with occasional interbeds of well-sorted fine- to medium-grained sand.

The Pliocene San Joaquin Formation consists of alternating beds of clay, silt, sand, and conglomerate. The sand and conglomerate beds contain fossils indicative of deposition in marine to non-marine conditions.

Major Sources of Recharge

Groundwater recharge is primary from seepage from the various streams that cross the subbasin. The cities of Coalinga, in the northern portion of the subbasin, and Avenal, near the center import water for municipal purposes. The state prisons near Coalinga and Avenal also use imported water. Additional recharge may occur because of this water use. It is estimated that approximately 4,000 acre-feet per year of applied water is recharged within the subbasin (DWR 2003). No data were found concerning the amount of natural recharge within the subbasin.

Land Use

Land use within the approximately 146,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-121.

Table 4-121. Land Use in the Pleasant Valley Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	2,000
Field Crops	14,500
Grain and Hay	30,500
Pasture	5,000
Truck, Nursery, and Berry Crops	10,500
Total	**62,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known water quality coalitions operating within the Pleasant Valley Subbasin.

Public water entities within the Pleasant Valley Groundwater Subbasin include: Pleasant Valley WD, City of Coalinga, Devil’s Den WD, and Green Valley WD. There are no identified private water entities within the subbasin.

The largest developed area in the subbasin is Coalinga with a population of approximately 17,000.

Fresno County has a Groundwater Management Ordinance restricting the extraction and transfer of groundwater outside of the County.

A County-issued permit is required for groundwater transfer, directly or indirectly, outside of the County, unless the action is exempted or a permit first obtained.

No known pertinent groundwater ordinances have been adopted by Kings County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR (Schuette et al. 2003) reported that between 1986 and 2003, 4,032 wells were sampled for pesticide residues in Fresno County and 229 wells in Kings County. Fresno County had 224 wells with verified detections and 369 wells with unverified detections while Kings County reported 4 wells with verified detections and 6 wells with unverified detections. Groundwater detections in Fresno County included: ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine. Groundwater detections in Kings County included: atrizine, diuron, and prometon.

Inorganic Constituents

TDS concentrations of groundwater in Pleasant Valley WD ranged from 1,000 to 3,000 mg/L with an average of 1,500 mg/L. The constituents in groundwater include calcium, magnesium, sodium, bicarbonates, chlorides, sulfates, and boron. The high TDS concentrations limit the usability of groundwater in the subbasin for most uses (DWR 2003).

SMALL GROUNDWATER BASINS

Panoche Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Panoche Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 33,184 acres (52 square miles), in San Benito County (Figure 4-4). Panoche Valley is an elongate northwest-southeast trending basin in the Coast Range Mountains.

No specific published information on the water-bearing units of the basin was identified. Limited well log information indicates that drilling in the basin has encountered gravels, sands, silts, and clays. These deposits are believed to be recent alluvium, Quaternary nonmarine terrace deposits, and Plio-Pleistocene nonmarine sediments (DWR 2003).

Major Sources of Recharge

Information regarding recharge of groundwater was not identified. However, groundwater levels have generally risen over 40 feet throughout the basin since the 1970s. The rise in water levels is believed to be due to recovery from past periods of pumping for agricultural uses (DWR 2003). Groundwater recharge in the basin probably occurs from percolation of precipitation and infiltration from ephemeral streams in the area.

Land Uses

Land use within the approximately 33,084-acre basin is shown on Figure 4-6. According to land use data, approximately 44 acres are planted with deciduous fruits and nuts with an additional 62 acres being used for activities that are semiagricultural or incidental to agriculture (Table 4-122). Extensive areas of alfalfa and cotton were cultivated in the 1950s and 1960s however, reconnaissance of the basin in 2001 identified one vineyard of less than 20 acres and one walnut orchard of less than 20 acres as the only irrigated agriculture within the basin (DWR 2003).

Table 4-122. Land Use in the Panoche Valley Groundwater Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	44	0.13
Grain and Hay	7,948	24.02
Vineyards	27	0.08
Truck, Nursery, and Berry Crops	9	0.03
Semiagricultural and Incidental	62	0.19
Subtotal	8,090	24.45
Native		
Native Vegetation	24,994	75.55
Subtotal	24,994	75.55
Total	**33,084**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions or public water entities in the Panoche Valley Groundwater Basin. There are no major urban areas in the basin.

No ordinances or regulations regarding groundwater were identified in San Benito County.

Water Quality

Data were available for groundwater samples collected from 26 wells between 1954 and 1988. TDS values for these samples ranged from 394 to 3,530 mg/L (DWR 2003). No analytical data for analysis of pesticides or nitrates in groundwater were identified.

Kern River Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Kern River Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 79,432 acres (124 square miles) in Kern County (Figure 4-4). The basin is irregularly shaped reflecting the shape of the Kern River drainage in the southern Sierra Nevada.

Water-bearing units in the basin consist primarily of recent alluvium and to a lesser extent older alluvium. The alluvium is derived from surrounding granitic and metamorphic rocks. The highest producing wells are located near the valley axis and near Lake Isabella (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation along the valley margins and infiltration from flow in the north and south forks of the Kern River and their tributaries (DWR 2003).

Land Uses

Land use within the approximately 79,432-acre basin is shown on Figure 4-6. According to land use data, approximately 4,549 acres are agricultural with about 97 acres in semiagricultural or incidental to agriculture land uses (Table 4-123).

Table 4-123. Land Use in the Kern River Valley Groundwater Basin

DWR Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	7	0.01
Grain and Hay	777	0.98
Pasture	2,931	3.69
Truck, Nursery, and Berry Crops	693	0.87
Idle	44	0.06
Semiagricultural and Incidental	97	0.12
Subtotal	4,549	5.73
Urban		
Urban—unclassified	2,256	2.84
Urban Landscape	75	0.09
Urban Residential	2,342	2.95
Commercial	137	0.17
Industrial	57	0.07
Vacant	122	0.15
Subtotal	4,988	6.28
Native		
Native Vegetation	33,939	42.73
Riparian	3,008	3.79
Water	10,644	13.40
Subtotal	47,591	59.91
FRAP Land Use Type		
Barren	78	0.10
Conifer	247	0.31
Hardwood	1,770	2.23
Herbaceous	2,205	2.78
Shrub	7,527	9.48
Urban	375	0.47
Desert	10,103	12.72
Subtotal	22,304	28.08

DWR Land Use	Acreage of Land Use	Percent of Land Use
Total	**79,432**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Kern River Valley Groundwater Basin. There are no identified public water entities in the basin and private water entities include Kern River Valley Water Company, Erskine Creek Water Company, James Water System, and Mountain Mesa Water Company. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds, including those through joint water conveyance facilities and sales to owners of water conveyance facilities. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 58 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Based on samples from 11 wells, TDS values range from 253 to 480 mg/L with an average of 378 mg/L. Iron and manganese have been detected at concentrations above applicable secondary MCLs in samples collected from wells along the Kern Canyon Fault. Nitrates were detected at concentration exceeding the MCL in samples collected from 5 of 76 wells sampled from 1994 to 2000 (DWR 2003).

Walker Basin Creek Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Walker Basin Creek Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 7,644 acres (12 square miles), in Kern County (Figure 4-4). The basin is a shallow alluvial basin in the southern Sierra Nevada.

The basin fill consists of alluvial sediments up to 150 feet thick with an average thickness of approximately 70 feet. A limited number of well logs in the basin identify decomposed granitic rock, sand, clay, and minor gravel (DWR 2003).

Major Sources of Recharge

Groundwater recharge appears to occur by percolation of precipitation and infiltration from ephemeral and spring-fed perennial streams entering the basin (DWR 2003).

Land Uses

Land use within the approximately 7,644-acre basin is shown on Figure 4-6. According to land use data, approximately 1,347 acres are agricultural with another 17 acres in uses that are semiagricultural or incidental to agriculture (Table 4-124).

Table 4-124. Land Use in the Walker Basin Creek Valley Groundwater Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	39	0.51
Field Crops	111	1.46
Grain and Hay	214	2.80
Pasture	799	10.45
Truck, Nursery, and Berry Crops	168	2.19
Semiagricultural and Incidental	17	0.22
Subtotal	1,347	17.62
Urban		
Urban Residential	381	4.98
Subtotal	381	4.98
Native		
Native Vegetation	5,917	77.40
Water	23	0.30
Subtotal	5,917	77.40
Total	**7,644**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations,

There are no identified water quality coalitions, public water entities, or private water entities in the Walker Basin Creek Valley Groundwater Basin. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

No data were identified describing groundwater quality in the basin.

Cummings Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cummings Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 10,019 acres (16 square miles), in Kern County (Figure 4-4). The basin is bounded on the north by the Sierra Nevada and on the south by the Tehachapi Mountains. Ridges on the east and west side of the basin connect the mountain ranges.

Water-bearing units in the basin consist of alluvium deposited in alluvial fans and on floodplains. The alluvial deposits are up to 450 feet thick with sands and gravels on the edge of the basin becoming finer grained towards the center of the basin (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and infiltration from ephemeral streams along the margins of the basin. Thick clays in the center of the basin restrict infiltration on the valley floor (DWR 2003).

Land Uses

Land use within the approximately 10,019-acre basin is shown on Figure 4-6. According to land use data, approximately 2,667 acres are agricultural with about 119 acres in uses that are semiagricultural or incidental to agriculture (Table 4-125).

Table 4-125. Land Use in the Cummings Valley Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	93	0.92
Grain and Hay Crops	334	3.33
Field Crops	508	5.07
Pasture	1,165	11.63
Semiagricultural and Incidental	119	1.19

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Truck, Nursery, and Berry Crops	448	4.48
Subtotal	2,667	26.62
Urban		
Urban—unclassified	25	0.25
Urban Residential	723	7.22
Commercial	214	2.13
Industrial	8	0.08
Vacant	4	0.04
Subtotal	974	9.72
Native		
Native Vegetation	6,333	63.21
Water Surface	46	0.46
Subtotal	6,379	63.66
Total	**10,019**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Cummings Valley Groundwater Basin. The groundwater basin is adjudicated and the Tehachapi-Cummings County Water District (TCCWD) is the watermaster. The only identified public water entity is the TCCWD with private water entities including the Stallion Springs Community Services District and the Bear Valley Community Services District. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 15 wells in the basin from 1994 to 2000 for analysis of pesticides. There was one detection of a pesticide at a concentration above an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Groundwater in the basin is primarily a calcium-bicarbonate type with an average TDS of 344 mg/L. Analysis of groundwater samples collected from 15 wells from 1994 to 2000 did not detect nitrates at a concentration exceeding the MCL (DWR 2003).

Tehachapi Valley West Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Tehachapi Valley West Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 14,908 acres (23 square miles), in Kern County (Figure 4-4). The basin lies in the western half of Tehachapi Valley and is bounded on the north by the Sierra Nevada and on the south by the Tehachapi Mountains.

Quaternary alluvium, up to 600 feet thick, is the primary water-bearing unit in the basin (DWR 2003). Lithologic descriptions of the Quaternary alluvium were not available.

Major Sources of Recharge

Groundwater recharge in the basin consists of percolation of stream flow within the basin and to a lesser extent percolation of precipitation (DWR 2003).

Land Uses

Land use within the approximately 14,908-acre basin is shown on Figure 4-6. According to land use data, approximately 1,143 acres are used for agricultural activities with about 36 acres in uses semiagricultural or incidental to agriculture (Table 4-126).

Table 4-126. Land Use in the Tehachapi Valley West Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	322	2.16
Grain and Hay Crops	403	2.70
Pasture	45	0.30
Field Crops	284	1.90
Semiagricultural and Incidental	36	0.24
Truck, Nursery, and Berry Crops	52	0.35
Subtotal	1,143	7.66
Urban		
Urban—unclassified	1,040	6.97

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Urban Residential	3,071	20.60
Urban Landscape	52	0.35
Vacant	212	1.42
Subtotal	4,375	29.35
Native		
Native Vegetation	9,194	61.67
Water Surface	92	0.62
Subtotal	9,286	62.29
Total	**14,908**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Tehachapi Valley West Groundwater Basin. The Tehachapi Valley West Groundwater Basin is an adjudicated basin. The TCCWD is the watermaster. Identified public water entities within the basin include TCCWD, City of Tehachapi, and Golden Hills Community Services District. The only identified private water entity in the basin is the Ashtown Mutual Water System. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticide and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 23 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Based on data from 3 wells, TDS values ranged from 280 to 365 mg/L. Groundwater samples were collected from 30 wells in the basin from 1994 to 2000 for analysis of nitrates. Nitrates were detected at concentrations exceeding the MCL in samples collected from two of the wells (DWR 2003).

Castaic Lake Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Castaic Lake Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 3,566 acres (6 square miles), in Kern County (Figure 4-4). Castaic Lake Valley is a "Y" shaped basin formed by the Garlock Fault and Grapevine Creek in the Tehachapi Mountains. Castaic Lake is a sag pond along the Garlock Fault (DWR 2003).

No data were found describing the water-bearing materials in the basin. Castaic Lake is a Quaternary playa where deposits typically consist of silts and clays that yield little water (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and infiltration from flow in Cuddy Creek and other ephemeral and spring-fed perennial streams that flow into the basin (DWR 2003).

Land Uses

Land use within the approximately 3,566-acre basin is shown on Figure 4-6. According to land use data, approximately 232 acres are used as pasture with no other identified agricultural uses in the basin (Table 4-127).

Table 4-127. Land Use in the Castaic Lake Valley Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Urban		
Urban—unclassified	47	1.30
Vacant	2	0.07
Subtotal	49	1.37
Native		
Native Vegetation	60	1.68
Subtotal	60	1.68
FRAP Land Use Type		
Barren	26	0.72
Conifer	30	0.84
Hardwood	664	18.62
Herbaceous	1,012	28.38
Shrub	363	10.18
Urban	568	15.93
Pasture	232	6.51
Water	312	8.75

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Wetland	206	5.78
Desert	44	1.23
Subtotal	3,457	96.95
Total	**3,566**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions or private water entities in the Castaic Lake Valley Groundwater Basin. The only identified public water entities within the basin are the Tejon-Castaic Water District and Lebec County Water District. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 6 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Measured TDS values for samples collected from three wells ranged from 570 to 605 mg/L. Groundwater samples were collected from 8 wells in the basin from 1994 to 2000 for nitrate analyses. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed. The only reported impairment to water quality was a detection of fluoride above the MCL in one well (DWR 2003).

Vallecitos Creek Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Vallecitos Creek Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 15,107 acres (24 square miles), in San Benito County (Figure 4-4). The basin is a northwest-southeast trending synclinal valley within the Coast Range Mountains.

Very limited information was identified regarding the water-bearing units in the basin. The valley reportedly contains Quaternary alluvium surrounded by Plio-Pleistocene nonmarine sediments and Miocene to Paleocene marine sediments. It is likely that water-bearing materials are restricted to shallow alluvium in the center of the valley (DWR 2003).

Major Sources of Recharge

Information regarding recharge of groundwater was not identified. Groundwater recharge in the basin probably occurs from percolation of precipitation and infiltration from ephemeral streams in the area.

Land Uses

Land use within the approximately 15,107-acre basin is shown on Figure 4-6. According to land use data, there are no agricultural land uses in the basin (Table 4-128).

Table 4-128. Land Use in the Vallecitos Creek Valley Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	15,107	100
Total	**15,107**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions or water entities in the Vallecitos Creek Valley Groundwater Basin. There are no major urban areas in the basin.

No ordinances or regulations regarding groundwater were identified in San Benito County.

Water Quality

No water quality data were identified within the basin.

Brite Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Brite Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 3,170 acres (5 square miles), in Kern County (Figure 4-4). The basin is a northwest to southeast trending valley bounded on the north by the Sierra Nevada and on the south by the Tehachapi Mountains. The basin is separated from Cummings Valley Groundwater Basin to the west and Tehachapi Valley West Groundwater Basin to the east by low lying ridges.

The primary water-bearing unit in the basin is alluvium deposited in alluvial fans on the edges of the valley and on floodplains in the center of the valley. The alluvium has a maximum thickness of approximately 500 feet (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and infiltration from flow in Brite Creek and other ephemeral streams in the valley. The TCCWD owns and operates a storage and recharge facility for water received from the State Project Water (DWR 2003).

Land Uses

Land use within the approximately 3,170-acre basin is shown on Figure 4-6. According to land use data, approximately 282 acres in the basin are used for agricultural purposes with another 26 acres in uses semiagricultural or incidental to agriculture (Table 4-129).

Table 4-129. Land Use in the Brite Valley Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	174	5.49
Grain and Hay Crops	69	2.17
Pasture	19	0.60
Vineyards	5	0.17
Semiagricultural and Incidental	26	0.82
Truck, Nursery, and Berry Crops	14	0.46
Subtotal	308	9.70
Urban		
Urban Residential	132	4.18
Commercial	72	2.27
Subtotal	205	6.45
Native		
Native Vegetation	2,610	82.32

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Water Surface	48	1.53
Subtotal	2,658	83.84
Total	**3,170**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Brite Valley Groundwater Basin. Brite Valley Groundwater Basin is an adjudicated basin. The TCCWD is the watermaster. The only identified water entity within the basin is the TCCWD. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Groundwater within the basin appears to be a calcium-bicarbonate type water with an electrical conductivity ranging from 550 to 770 micromohs per centimeter (DWR 2003). No groundwater analytical data for pesticides or nitrates were identified from within the Brite Valley Groundwater Basin.

Cuddy Canyon Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cuddy Canyon Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 3,299 acres (5 square miles), in Kern County (Figure 4-4). The basin is within the San Emigdio Mountains in a series of valleys formed along the San Andreas Fault.

Water-bearing units in the basin consist of recent and older alluvium deposited in the Cuddy Creek drainage. These deposits consist of poorly sorted silty sand and gravel (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and infiltration from flow in Cuddy Creek and other ephemeral streams in the valley (DWR 2003).

Land Uses

Land use within the approximately 3,299-acre basin is shown on Figure 4-6. According to land use data, approximately 7 acres are used as pasture with no other identified agricultural uses in the basin (Table 4-130).

Table 4-130. Land Use in the Cuddy Canyon Valley Groundwater Basin

FRAP Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture	7.413	0.22
Barren	270	8.17
Conifer	427	12.94
Hardwood	51	1.54
Herbaceous	379.2	11.49
Shrub	1,564	47.39
Urban	602	18.24
Desert	0.091	0.003
Total	**3,299**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Cuddy Canyon Valley Groundwater Basin. The only identified public entity within the basin is the Frazier Park Public Utility District. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watershedsFour exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 5 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Groundwater quality in the basin has not been characterized by DWR. Measured TDS values for samples collected from two wells ranged from 690 to 695 mg/L. Groundwater samples were collected from 5 wells in the basin for nitrate analyses from 1994 to 2000. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed. The only identified detections above an applicable MCL in the basin include fluoride and radiological constituents (DWR 2003).

Cuddy Ranch Area Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cuddy Ranch Area Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 4,186 acres (7 square miles), in Kern County (Figure 4-4). The basin is within the San Emigdio Mountains in a series of valleys formed along the San Andreas Fault.

Deposits in the basin include sandstone, conglomerate, siltstone, and claystone on the Tertiary Caliente Formation. The Tertiary deposits are overlain by Pleistocene and recent alluvium composed of unconsolidated gravels, sands, and silts. Abundant clays in the south end of the basin suggest the presence of lacustrine and/or marsh deposits that may indicate the basin was recently closed (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to occur by percolation of precipitation and infiltration from ephemeral streams in the area (DWR 2003).

Land Uses

Land use within the approximately 4,186-acre basin is shown on Figure 4-6. According to land use data, approximately 290 acres are used as pasture with no other identified agricultural uses in the basin (Table 4-131).

Table 4-131. Land Use in the Cuddy Ranch Area Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	290	6.92
Subtotal	290	6.92
Urban		
Urban—unclassified	17	0.41
Subtotal	17	0.41
Native		
Native Vegetation	3,262	77.93

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Subtotal	3,262	77.93
FRAP Land Use Type		
Conifer	267	6.37
Herbaceous	30	0.72
Shrub	102	2.44
Urban	218	5.21
Subtotal	617	14.73
Total	**4,186**	**100**

Coalitions, Water Districts, Major Urban Areas — Pertinent Ordinances or Regulations

There are no identified water quality coalitions, public water entities, or private water entities in the Cuddy Ranch Area Groundwater Basin. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 5 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

The measured TDS of groundwater in the basin ranges from 690 to 695 mg/L. Groundwater samples were collected from 6 wells in the basin for nitrate analyses from 1994 to 2000. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed (DWR 2003).

Cuddy Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cuddy Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 3,465 acres (5 square miles), in Kern County (Figure 4-4). The valley is an elongate east-west trending valley in the San Emigdio Mountains.

Water-bearing units in the basin consist of older alluvial and terrace deposits and younger alluvium. These deposits have a maximum thickness of approximately 450 feet and are underlain by crystalline bedrock or undifferentiated Tertiary sediments (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to occur primarily by percolation of precipitation. Recharge from septic systems in the Pinion Pines and Pineridge developments supplements the natural recharge (DWR 2003).

Land Uses

Land use within the approximately 3,465-acre basin is shown on Figure 4-6. According to land use data, there are no identified agricultural uses in the basin (Table 4-132).

Table 4-132. Land Use in the Cuddy Valley Groundwater Basin

FRAP Land Use Type	Acreage of Land Use	Percent of Land Use
Conifer	1,615	46.62
Hardwood	10.3	0.30
Herbaceous	917	26.46
Shrub	714	20.61
Urban	199	5.73
Water	9.9	0.29
Total	**3,465**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions, public water entities, or private water entities in the Cuddy Valley Groundwater Basin. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 5 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Groundwater quality in the basin has not been characterized by DWR. TDS values in the basin range from 325 to 645 mg/L (DWR 2004). Groundwater quality appears to be better in the western portion of the basin with high levels of iron and manganese in samples collected from wells in the eastern portion of the basin. Groundwater samples were collected from 10 wells in the basin for nitrate analyses from 1994 to 2000. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed (DWR 2003).

Mil Portero Area Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Mil Portero Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 2,309 acres (4 square miles), in Kern County (Figure 4-4). The basin is irregularly shaped and within the San Emigdio Mountains.

The basin consists of stream-derived alluvium and mudflow debris with a maximum thickness estimated at 400 feet. This material is underlain by the Tertiary Caliente Formation that is composed of sandstone, conglomerate, siltstone, and claystone (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and springs emanating from canyon walls on the south side of the basin. Natural recharge is supplemented by over 1,900 septic systems in the basin (DWR 2003).

Land Uses

Land use within the approximately 2,309-acre basin is shown on Figure 4-6. According to land use data, there are no agricultural land uses within the basin (Table 4-133).

Table 4-133. Land Use in the Mil Portero Area Groundwater Basin

FRAP Land Use Type	Acreage of Land Use	Percent of Land Use
Conifer	1,325	57.37
Herbaceous	61	2.65
Shrub	98	4.26
Urban	825	35.72
Total	**2,309**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions or public water entities in the Mil Portero Groundwater Basin. The only identified private water entity within the basin is the Mil Portero Mutual Water Company. There are no major urban areas in the basin.

Pertinent Ordinances or Regulations

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticide and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 6 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Measured TDS values for samples collected from wells in the basin range from 372 to 657 mg/L. Secondary water standards for aluminum, iron, and manganese are exceeded in the water supply of the Mil Portero Mutual Water Company. Groundwater samples were collected from 7 wells for nitrate analyses in the basin. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed (DWR 2003).